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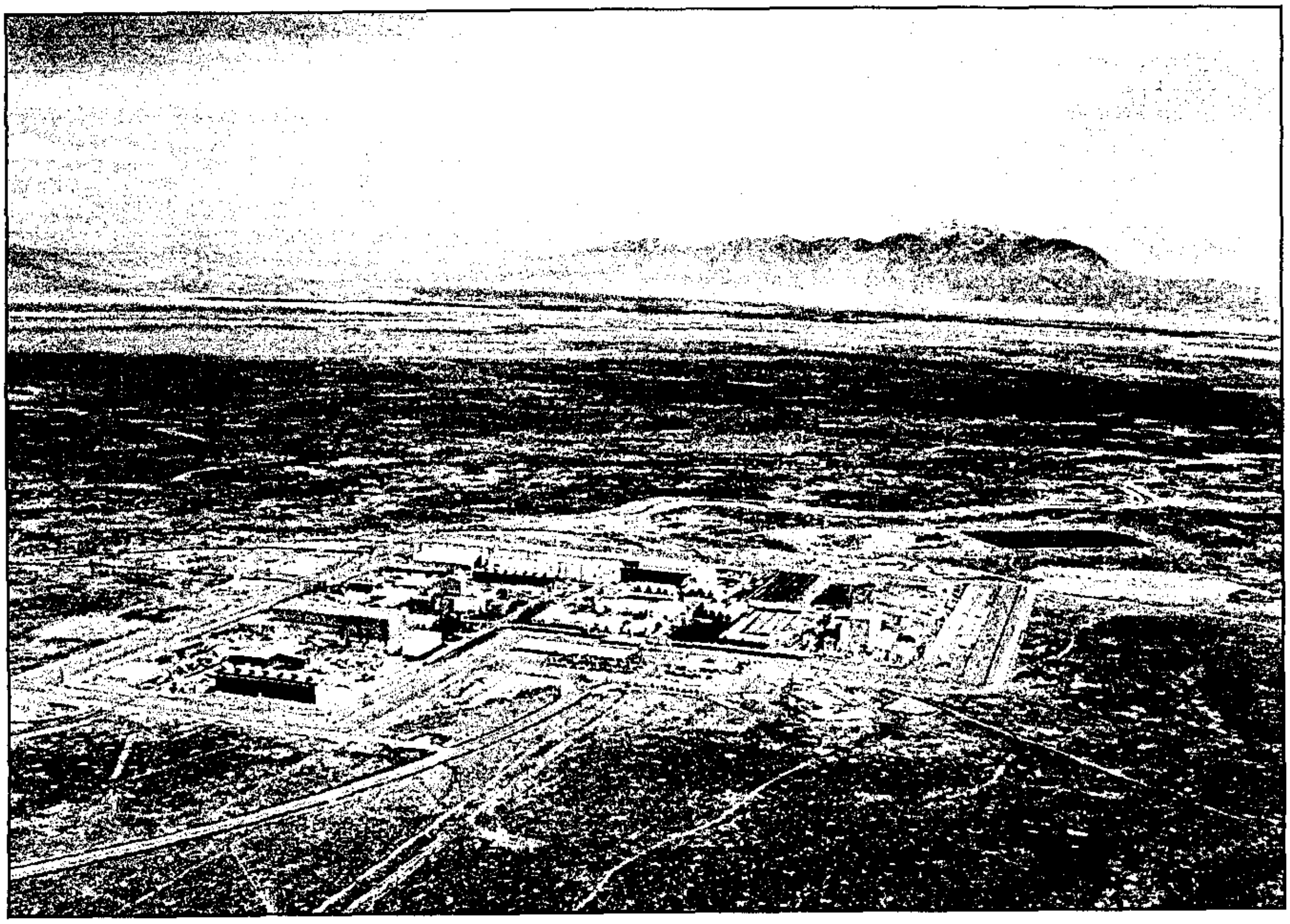
September 30, 1998

STATE OF IDAHO
DIVISION OF ENVIRONMENTAL QUALITY

Final Record of Decision

Naval Reactors Facility



Operable Unit 8-08
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

Final Record of Decision
Naval Reactors Facility
Operable Unit 8-08

September 30, 1998

Prepared for the
U.S. Department of Energy
Pittsburgh Naval Reactors Office
Idaho Branch Office
P. O. Box 2469
Idaho Falls, Idaho 83403-2469

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PART I
DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Naval Reactors Facility, Waste Area Group 8
Operable Unit 8-08
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial actions for nine sites in Operable Unit (OU) 8-08 at the Naval Reactors Facility (NRF) located on the Idaho National Engineering and Environmental Laboratory (INEEL). NRF has been designated as Waste Area Group (WAG) 8, which is one of ten WAGs at the INEEL identified by the U.S. Environmental Protection Agency (EPA) Region 10, the Idaho Department of Health and Welfare (IDHW), and the U.S. Department of Energy (DOE) in the Federal Facilities Agreement and Consent Order (FFA/CO). These remedial actions were selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This document also presents the decision of performing no remedial action for 55 additional sites at WAG 8. The decisions made in this document are based on information in the Administrative Record file for NRF.

The EPA and IDHW concur with the selected remedial actions for the nine sites of concern and the no remedial action decision for the 55 remaining sites.

ASSESSMENT OF THE SITE

The FFA/CO Action Plan describes OU 8-08 as the WAG 8 Comprehensive Remedial Investigation/Feasibility Study (RI/FS) and includes several potential radiological sites. There have been nine operable units and 87 sites identified at NRF. Each operable unit contains a site or group of sites with similar characteristics. With the exception of 18 radiological sites and two post-RI/FS new sites, each site has been investigated under a previous assessment. These previous assessments evaluated the sites individually without respect to their proximity to other sites. Previous decision documents have been issued for 23 of the 87 sites. Decisions for the remaining 64 sites are provided in this Record of Decision. One purpose of the Comprehensive RI/FS was to thoroughly investigate 18 potential radiological sites that were not previously investigated. Another purpose of the Comprehensive RI/FS was to assess the potential cumulative, or additive, effects of all identified sites at NRF on human health and the environment including potential impacts to the groundwater. The 23 sites with previous decision documents were included in the comprehensive assessment to ensure the specified action or no action delineated in the decision document remains protective of human health and the environment from a cumulative perspective.

Thirteen of the 23 sites addressed by previous decision documents were not part of an operable unit and were determined to be no action sites under a Consent Order and Compliance Agreement (COCA) which preceded the FFA/CO. Ten other sites in OUs 8-05, 8-06, and 8-07 were addressed under a previous Record of Decision. The Comprehensive RI/FS determined that the decisions made for the 23 sites were appropriate and no additional human health or environmental concerns exist from a cumulative perspective.

This Record of Decision addresses 64 sites by providing selected remedial actions for nine sites and recommending no remedial action for 55 sites. Fifty-five sites present no risk or an acceptable risk to human health or the environment, and therefore do not require a remedial action. The no remedial action sites are identified as follows: NRF-03, 06, 08, 33, 40, 41, and 53 in OU 8-01; NRF-09, 37, 38, 42, 47, 52A, 52B, 54, 55, 61, 64, and 68 in OU 8-02; NRF-10, 15, 18A, 18B, 20, 22, 23, 45, and 56 in OU 8-03, NRF-28, 29, 31, 44, 58, 62, 65, 69, 70, 71, 72, 73, 74, 75, 76, and 77 in OU 8-04; NRF-02, 13, 16, 32, 43, 66, 79, and 81 in OU 8-08; OU 8-09; and NRF-82 and 83 which are not included in an OU. Actual or threatened releases of hazardous substances from nine sites, if not addressed by implementing the response actions selected in this Record of Decision, may present an imminent and substantial endangerment to human health and the environment. These sites are NRF-11, 12A, 12B, 14, 17, 19, 21A, 21B, and 80 in OU 8-08.

DESCRIPTION OF REMEDY

Operable Unit 8-08 consists of 18 potential radiological sites and the sites addressed in the comprehensive assessment of all identified sites at NRF. The assessment of Operable Unit 8-08 was accomplished in the NRF Comprehensive RI/FS. The RI/FS tasks were to thoroughly investigate 18 sites not previously evaluated (radiological areas including one OU 8-03 site) and to comprehensively assess the cumulative risk posed by all NRF sites. The site assessments for the 18 radiological areas resulted in the identification of nine sites of concern. The comprehensive assessment included all sites at NRF and did not identify any additional sites of concern. Twenty-three of the 87 identified sites at NRF were addressed in previous decision documents, therefore, this Record of Decision addresses decisions made for the remaining 64 sites. Of the 64 sites, 55 do not require additional action. Forty-three of the 55 sites are recommended for No Action and the other 12 of 55 sites are recommended for No Further Action. A No Action decision indicates the sites have no source present or a source is present at a level with an acceptable human health and environment risk for unrestricted use. A No Further Action decision indicates the site has a source or potential source present that does not have an exposure route available under current site conditions. Because the No Further Action decision potentially results in hazardous substances remaining onsite above risk-based levels, a CERCLA review will be conducted within five years after commencement of final remedial actions at NRF to ensure that the No Further Action decision remains effective.

For the protection of human health and the environment, remedial action objectives and goals were developed for the nine sites of concern. The remedial action objectives, associated goals, and the general actions necessary to meet the objectives and goals are as follows:

- Soil contaminated with cesium-137 greater than 16.7 picocuries per gram (pCi/g) will be excavated and/or covered with an engineered cap to prevent external gamma radiation exposure from exceeding an excess cancer risk of 1 in 10,000 for the future 100-year residential receptor.
- Soil contaminated with strontium-90 greater than 45.6 pCi/g will be excavated and/or covered to prevent ingestion of soil and food crops from exceeding an excess cancer risk of 1 in 10,000 for the future 100-year residential receptor.
- Soil contaminated with lead greater than 400 parts per million (ppm) will be excavated and/or covered to prevent direct contact with lead contaminated soil.
- To prevent the release of contaminated soils, an adequate cover will be used to inhibit erosion by natural processes and biotic intrusion by resident plant or animal species.
- Contaminated soil will be excavated and/or covered, as outlined above, to prevent exposure to contaminants of concern that may cause adverse effects on resident species populations.

In order to meet the objectives and goals for the protection of human health and the environment, the selected remedy for the nine sites of concern consists of limited excavation, disposal, and containment. The major components of the selected remedy include:

- Excavating contaminated soil above remediation goals and debris from six of the nine sites;
- Consolidating the excavated soil at one site (S1W Leaching Beds);
- Disposing of radiological, non-hazardous debris to an INEEL disposal facility or an appropriate off-site (away from INEEL) disposal facility and, if necessary, disposing of radiological, hazardous debris as a mixed waste per the INEEL Site Treatment Plan;
- Constructing engineered covers primarily of native earthen materials in two areas that would cover the three sites not excavated, which includes the site where soil was consolidated. Cover materials will be determined in the Remedial Design/Remedial Action Work Plan;
- Radiation surveys and soil sampling during excavation;
- Soil and groundwater sampling to monitor any potential releases from the covered areas;
- Periodic inspection and maintenance of covers to ensure their integrity;
- Establishing fencing or other barriers and land use restrictions.

The possibility exists that contaminated environmental media not identified in the FFA/CO or in this comprehensive investigation will be discovered in the future as a result of routine operations, maintenance activities, and decontamination and dispositioning activities at NRF. Upon discovery of a new contaminant source by DOE, IDHW, or EPA, the contaminant source will be evaluated and appropriate response actions taken in accordance with the FFA/CO.

STATUTORY DETERMINATION

The selected remedy for the nine sites of concern is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial actions, and is cost effective. This remedy utilizes permanent solutions; however, it does not satisfy the statutory preference for treatment as a principal element of the remedy. Treatment was found to be ineffective, difficult to implement, and/or not cost effective. The contaminated soils can be reliably contained at NRF.

Because this remedy may result in hazardous or radiological substances remaining on site above risk-based levels, a review will be conducted within five years after commencement of final remedial actions to ensure that the remedy continues to provide adequate protection of human health and the environment.

The agencies agree that no remedial action be taken for 55 of the 64 sites. For 12 of the 55 sites, where no action is being taken because an exposure route is not present under current site conditions (No Further Action decision), the site conditions will be reviewed at least every five years to ensure that performing no action remains protective of human health and the environment. For the 43 of 55 sites with a No Action decision, follow-up reviews are not required.

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Signature Sheet

Signature sheet for the Record of Decision for Operable Unit 8-08, located in Waste Area Group 8, Naval Reactors Facility at the Idaho National Engineering and Environmental Laboratory, between the U.S. Department of Energy and the Environmental Protection Agency, with concurrence by the Idaho Department of Health and Welfare.

Chuck Clarke

Chuck Clarke, Regional Administrator
Region 10
U.S. Environmental Protection Agency

9/29/98

Date

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Signature Sheet

Signature sheet for the Record of Decision for Operable Unit 8-08, located in Waste Area Group 8, Naval Reactors Facility at the Idaho National Engineering and Environmental Laboratory, between the U.S. Department of Energy and the Environmental Protection Agency, with concurrence by the Idaho Department of Health and Welfare.

J.M. Sandoval, Assistant Administrator

Wallace N. Cory, Administrator
Division of Environmental Quality
Idaho Department of Health and Welfare

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Date

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Signature Sheet

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Theron M. Bradley, Jr.

Theron M. Bradley, Manager
U.S. Department of Energy
Naval Reactors Idaho Branch Office

Sept 24, 1998
Date

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Acronyms

AOC	area of contamination
ARARs	applicable or relevant and appropriate requirements
A1W	Large Ship Reactor Prototype
BB	Butler Building
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminants of concern
COCA	Consent Order and Compliance Agreement
COPC	contaminants of potential concern
DOE	Department of Energy
ECF	Expended Core Facility
EPA	Environmental Protection Agency
FFA/CO	Federal Facility Agreement and Consent Order
HEAST	Health Effects Assessment Summary Tables
HQ	hazard quotient
IDHW	Idaho Department of Health and Welfare
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IRIS	Integrated Risk Information System
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHPA	National Historic Preservation Act
NPL	National Priorities List
NRF	Naval Reactors Facility
NRHP	National Register of Historic Places
OU	operable unit
PCB	polychlorinated biphenyl
pCi/g	picocurie per gram
ppb	parts per billion
ppm	parts per million
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RWMC	Radioactive Waste Management Complex
SDP	Bettis Atomic Power Laboratory Site Development Plan
SLERA	Screening Level Ecological Risk Assessment
SRPA	Snake River Plain Aquifer
S5G	submarine reactor plant prototype
S1W	Submarine Thermal Reactor Prototype
TRA	Test Reactor Area
UCL	upper confidence limit
USGS	United States Geological Survey
UST	underground storage tank
WAG	Waste Area Group

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PART II
DECISION SUMMARY

1.0 Site Background

1.1 Idaho National Engineering and Environmental Laboratory

The Idaho National Engineering and Environmental Laboratory (INEEL) is a government facility managed by the U.S. Department of Energy (DOE), located 32 miles west of Idaho Falls, Idaho, and occupies 890 square miles (mi^2) of the northeastern portion of the Eastern Snake River Plain. Facilities at the INEEL are primarily dedicated to nuclear research, development, and waste management.

The INEEL was established in 1949 as the National Reactor Testing Station by the United States Atomic Energy Commission as a site for building, testing, and operating nuclear reactors, fuel processing plants, and support facilities with maximum safety and isolation. In 1974, the area was designated as the Idaho National Engineering Laboratory to reflect the broad scope of engineering activities conducted there. The name was changed to the INEEL in 1997 to reflect the redirection of its mission to include environmental research.

The U.S. Government occupied portions of the INEEL prior to its establishment as the National Reactor Testing Station. During World War II, the U.S. Navy used about 270 mi^2 of the site as a gunnery range. The U.S. Army Air Corps once used an area southwest of the naval gunnery area as an aerial gunnery range. The present INEEL site includes all of the former military areas and a large adjacent area withdrawn from the public domain for use by the DOE. The former Navy administration shop, warehouse, and housing area are presently the Central Facilities Area of the INEEL.

The Bureau of Land Management manages the surrounding areas for multipurpose use. The developed area within the INEEL is surrounded by a 500 mi^2 buffer zone used for cattle and sheep grazing. Communities nearest to the INEEL are Atomic City (south), Arco (west), Butte City (west), Howe (northwest), Mud Lake (northeast), and Terreton (northeast). In the counties surrounding the INEEL, approximately 45% is agricultural land, 45% is open land, and 10% is urban. Sheep, cattle, hogs, poultry, and dairy cattle are produced; and potatoes, sugar beets, wheat, barley, oats, forage, and seed crops are cultivated. The U.S. Government or private individuals own most of the land surrounding the INEEL.

Fences and security personnel strictly control public access to facilities at the INEEL. State Highways 22, 28, and 33 cross the northeastern portion of the INEEL and U.S. Highways 20 and 26 cross the southern portion. A total of 90 miles of paved highways pass through the INEEL and is used by the general public.

1.2 Naval Reactors Facility

The Naval Reactors Facility (NRF) is located on the west central side of the INEEL, as shown on Figure 1, approximately 50 miles west of Idaho Falls, Idaho. NRF was established in 1949 as a testing site for the Naval Nuclear Propulsion Program. The Westinghouse Electric Company operates NRF for DOE, Office of Naval Reactors. NRF covers 7 square miles of which 80 acres are developed and, at various times, was occupied by up to 3,300 people. Approximately 650 Westinghouse employees and 390 long-term subcontractor employees are currently working at NRF. The nearest public roads to NRF are approximately 7 miles west, 10 miles north, and 10 miles south.

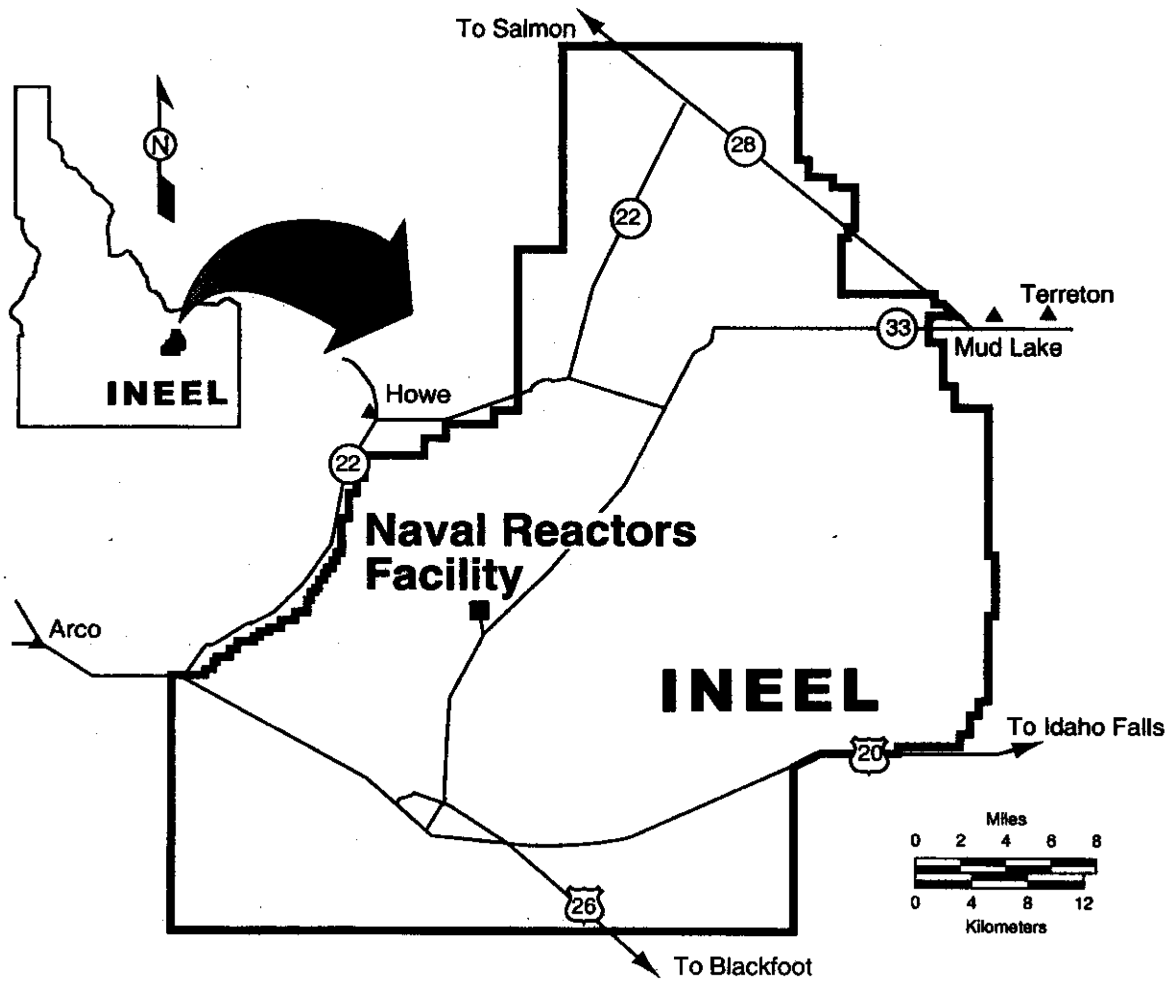

Figure 1. Location of the Naval Reactors Facility (Waste Area Group 8)

NRF consists of three Naval nuclear reactor prototype plants, the Expended Core Facility (ECF), and miscellaneous support buildings. Construction of the Submarine Thermal Reactor prototype (S1W) at NRF began in 1951. The prototype completed operation in 1989. The Large Ship Reactor Prototype (A1W) was constructed in 1958 and completed operation in January 1994. The submarine reactor plant prototype (S5G) was constructed in 1965 and completed operation in May 1995. The prototypes were used to train sailors for the nuclear navy and were used for research and development purposes. The Expended Core Facility, which receives, inspects, and conducts research on naval nuclear fuel, was constructed in 1958 and is still in operation.

1.3 Physical Characteristics

The INEEL is located on the northeastern portion of the Eastern Snake River Plain, a volcanic plateau that is composed primarily of volcanic rocks and relatively minor amounts of sediments. Underlying the INEEL is a series of basaltic flows containing sedimentary interbeds. The Snake River Plain Aquifer (SRPA) is the largest potable aquifer in Idaho, and underlies the Eastern Snake River Plain and the INEEL. The aquifer is approximately 200 miles long and 50 miles wide, and covers an area of approximately 9,600 mi^2. The depth to the SRPA at the INEEL varies from approximately 200 feet in the northeastern corner to approximately 900 feet in the southeastern corner. The distance between these extremes is 42 miles. The EPA designated the SRPA as a sole-source aquifer under the Safe Drinking Water Act on October 7, 1991. The aquifer possesses a high hydraulic conductivity on a large scale because of the presence of fractures in the basalt. Local hydraulic conductivity may vary greatly due to the heterogeneous distribution of the physical properties of the aquifer. Groundwater flow in the SRPA is to the south-southwest at rates between 1.5 to 20 feet per day. In the vicinity of NRF, recharge to the SRPA occurs by infiltration from the Big Lost River, Little Lost River and Birch Creek, and to a lesser extent by infiltration due to precipitation. The average annual precipitation at the INEEL is approximately 8.5 inches.

NRF is located in the central portion of the INEEL. The land surface at NRF is relatively flat, with elevations ranging from 4,835 feet towards the distal end of the NRF industrial waste ditch, which is located approximately one mile north of NRF, to 4,870 feet at the south end of NRF. NRF is not located in the 100-year flood plain, although parts of the INEEL are on the flood plain. A flood with a recurrence interval of 5,000 to 8,000 years is capable of inundating NRF.

NRF is located on the alluvial plain of the Big Lost River. The thickness of alluvial sediment in the vicinity of NRF ranges from several inches to in excess of 60 feet north of NRF. Most of the soil near NRF is mapped as sandy loam or loess. The loess is an accumulation of wind deposited silt sized particles. Near surface sediments at NRF consist of alluvial deposits of the Big Lost River and are composed of unconsolidated fluvial deposits of silt, sand, and pebble-sized gravel.

A complex sequence of basalt flows and sedimentary interbeds underlie NRF. The sedimentary interbeds vary in thickness and lateral extent and separate the basalt flows that underlie the surficial alluvium. Samples from basalt flows have been correlated into 23 flow groups that erupted from related source areas. Known source vents occur to the southwest, along what is referred to as the Arco volcanic rift zone, to the southeast along the axial volcanic zone, and to the north at Atomic Energy Commission Butte. The uneven alluvial thickness and undulating basalt surface at NRF are common of basalt flow morphology.

The SRPA occurs approximately 375 feet below NRF, and consists of a series of saturated basalt flows and interlayered pyroclastic and sedimentary material. Drinking water for employees at NRF comes from several production wells located in the central portion of the facility. Perched water, which sets above the regional water table, occurs in several locations beneath NRF. All perched water at NRF is associated with past or current large volume surface sources of water. The most significant perched water at NRF is located beneath the outfall of the NRF industrial waste ditch.

1.4 Ecological Characteristics

Fifteen distinctive vegetative cover types have been identified at the INEEL. The vegetation cover class at NRF is primarily shrub-steppe flats with sagebrush being the dominant species and providing the majority of habitat. No threatened, endangered, or otherwise regulated flora is known to be present in the NRF area.

The variety of habitats on the INEEL supports numerous species of reptiles, birds, and mammals. Several bird species warrant special concern because of their threatened status or sensitivity to disturbance. These species include the ferruginous hawk, bald eagle, prairie falcon, merlin, long-billed curlew, and burrowing owl. NRF is not known to be within a critical habitat for endangered or threatened species. The bald eagle, golden eagle, and American peregrine falcon have been observed, but are not know to frequent the area around NRF.

The Threatened Fish and Wildlife Act does not identify any fish or wildlife species of concern at NRF. Migratory waterfowl frequent areas of NRF, but the areas with potential remedial actions do not provide critical habitat. The Idaho Department of Fish and Game lists the ringneck snake, whose occurrence is considered to be INEEL-wide, as a Category C sensitive species. NRF is a disturbed industrial area with continuous human activity that contains little suitable habitat for most endangered, threatened or sensitive species. Potential remedial actions at NRF are not expected to affect these species, including adverse impacts to migratory waterfowl, because of the limited area of concern, the previously disturbed nature of the area, and the expected limited duration of any potential remedial actions.

1.5 Archeological and Historical Characteristics

The area around NRF has been surveyed for archeological or historical value. Although some archeological remnants have been found around NRF, areas with potential remedial actions do not contain any known archeological or historical items of value. These areas have been previously disturbed and archeological or historical remnants would not be expected. Therefore, the regulatory requirements associated with the preservation of antiquities and archeological materials and sites are not a concern.

The Idaho State Historical Society has identified the INEEL as containing properties potentially eligible for the National Register of Historic Places (NRHP). Several structures at NRF may be eligible for the NRHP and, therefore, would be accorded the same protection under the National Historic Preservation Act (NHPA) as if they were listed under the act. If potential remedial actions may adversely impact these structures, all applicable requirements established under the NHPA will be followed for the remedial actions.

2.0 Summary of CERCLA Activities at NRF

2.1 CERCLA Background at NRF

In 1987, a Consent Order and Compliance agreement (COCA) was established between DOE and the U.S. Environmental Protection Agency (EPA) pursuant to the Resource Conservation and Recovery Act (RCRA) Section 3008(h). The COCA required an initial assessment and screening of all solid and/or hazardous waste disposal areas at the INEEL and set up a process for conducting any necessary corrective actions. In 1989, the INEEL was placed on the National Priorities List (NPL) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). In 1991, the EPA, Idaho Department of Health and Welfare (IDHW) and DOE signed the Federal Facility Agreement and Consent Order (FFA/CO), which superceded the COCA. The FFA/CO established the procedural framework and schedule for developing, prioritizing, implementing, and monitoring response actions at the INEEL in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This agreement and the associated Action Plan defined the decision process for conducting assessments and investigations of potential contaminant release areas.

To better manage the environmental investigations under CERCLA, the INEEL was divided into ten Waste Area Groups (WAGs), of which NRF was designated as WAG 8. Within each WAG, all areas with a potential for past contaminant releases were identified as sites. Those sites with similar releases and migration pathways were grouped into operable units (OUs). A total of 87 known or suspected contaminant release sites, of which 71 were classified in nine OUs, were identified at NRF as requiring further study under the CERCLA process. Table 1 lists the OUs and sites associated with NRF. Four sites, NRF-12, NRF-18, NRF-21, and NRF-52, were each divided into two separate sites for evaluation purposes (included in the 87 total sites). Figure 2 shows the status and decisions made for each identified OU at NRF. Figure 3 shows the location of each site with respect to NRF. The site numbers shown on Figure 3 correspond to the site numbers given on Table 1. The remainder of this section summarizes the CERCLA process used to determine the decisions made for each site.

2.2 CERCLA Investigations

Each of the 87 sites required an investigation to determine potential risks to human health and the environment. Thirteen of the 87 sites were evaluated prior to the FFA/CO under the COCA and were not part of an OU. The remaining 74 sites were assessed as CERCLA-type investigations. The CERCLA investigations included Track 1, Track 2, and Remedial Investigation/Feasibility Study (RI/FS) type investigations. A Track 1 investigation involved sites that were believed to have a low probability of risk and sufficient information available to evaluate the sites and recommend a course of action. A Track 2 investigation involved sites that did not have sufficient data available to make a decision concerning a level of risk; for these sites, collection of additional data was necessary. An RI/FS is the most extensive investigation and attempts to characterize the nature and extent of contamination, to assess risks to human health and the environment from potential exposure to contaminants, and to evaluate cleanup actions. In addition to the investigations performed for each site through a Track 1, Track 2, or RI/FS process, a comprehensive RI/FS was performed to assess the potential cumulative, or additive, effects to human health and the environment from all sites at NRF.

Table 1. List of WAG 8 Sites

Operable Unit	Site Number[1]	Site Name
None		
	NRF-04	Top Soil Pit Area
	NRF-05	West Landfill
	NRF-07	East Landfill
	NRF-24	Demineralizer and Neutralization Facility
	NRF-25	Chemical Waste Storage Pad
	NRF-27	Main Transformer Yard
	NRF-30	Gatehouse Transformer
	NRF-34	Old Parking Lot Landfill
	NRF-39	Old Radiography Area
	NRF-46	Kerosene Spill
	NRF-57	S1W Gravel Pit
	NRF-60	Old Incinerator
	NRF-67	Old Transformer Yard
8-01		
	NRF-03	ECF Gravel Pit
	NRF-06	Southeast Landfill
	NRF-08	North Landfill
	NRF-33	South Landfill
	NRF-40	Lagoon Construction Rubble
	NRF-41	East Rubble Area
	NRF-63	A1W Construction Debris Area
8-02		
	NRF-09	Parking Lot Runoff Leaching Trenches
	NRF-37	Old Painting Booth
	NRF-38	ECF French Drain
	NRF-42	Old Sewage Effluent Ponds
	NRF-47	Site Lead Shack (Building #614)
	NRF-52A	Old Lead Shack (Location #1)
	NRF-52B	Old Lead Shack (Location #2)
	NRF-54	Old Boilerhouse Blowdown Pit
	NRF-55	Miscellaneous NRF Sumps and French Drains
	NRF-61	Old Radioactive Materials Storage and Laydown Area
	NRF-64	South Gravel Pit
	NRF-68	Corrosion Area Behind BB11
8-03		
	NRF-10	Sand Blasting Slag Trench
	NRF-15	S1W Acid Spill Area
	NRF-18A	S1W Spray Pond #1
	NRF-18B	S1W Spray Pond #2 and A1W Cooling Tower
	NRF-20	A1W Acid Spill Area
	NRF-22	A1W Painting Locker French Drain
	NRF-23	Sewage Lagoons
	NRF-45	Site Incinerator
	NRF-56	Degreasing Facility
8-04		
	NRF-28	A1W Transformer Yard
	NRF-29	S5G Oily Waste Spill
	NRF-31	A1W Oily Waste Spill

Operable Unit	Site Number[1]	Site Name
8-04 (con't)		
	NRF-44	S1W Industrial Wastewater Spill Area
	NRF-58	S1W Old Fuel Oil Tank Spill
	NRF-62	ECF Acid Spill Area
	NRF-65	Southeast Corner Oil Spill
	NRF-69	Plant Service Underground Storage Tank (UST) Diesel Spill
	NRF-70	Boiler House Fuel Oil Release
	NRF-71	Plant Service UST Gasoline Spill
	NRF-72	NRF Waste Oil Tank
	NRF-73	NRF Plant Services Varnish Tank
	NRF-74	Abandoned UST's Between the NRF Security Fences
	NRF-75	Fuel Oil Revetment Oil Releases
	NRF-76	Vehicle Barrier Removal
	NRF-77	A1W Fuel Oil Revetment Oil Releases
8-05		
	NRF-01	Field Area North of S1W
	NRF-51	West Refuge Pit #4
	NRF-59	Original S1W Refuse Pit
8-06		
	NRF-35	Lagoon Landfill #1
	NRF-36	Lagoon Landfill #2
	NRF-48	West Refuse Pit #1
	NRF-49	West Refuse Pit #2
	NRF-50	West Refuse Pit #3
	NRF-53	East Refuse Pits and Trenching Area
8-07		
	NRF-26	Industrial Waste Ditch
8-08		
	NRF-02	Old Ditch Surge Pond
	NRF-11	S1W Tile Drain Field and L-shaped Sump
	NRF-12A	Underground Piping to Leaching Pit
	NRF-12B	S1W Leaching Pit
	NRF-13	S1W Temporary Leaching Pit
	NRF-14	S1W Leaching Beds
	NRF-16	Radiography Building Collection Tanks
	NRF-17	S1W Retention Basins
	NRF-19	A1W Leaching Bed
	NRF-21A	Old Sewage Basin
	NRF-21B	Sludge Drying Bed
	NRF-32	S5G Basin Sludge Disposal Bed
	NRF-43	Seepage Basin Pumpout Area
	NRF-66	Hot Storage Pit
	NRF-79	ECF Water Pit Release
	NRF-80	A1W/S1W Radioactive Line Near BB19
	NRF-81	A1W Processing Building Area Soil
8-09		
	None	Interior Industrial Waste Ditch
New Sites		
	NRF-82	Evaporator Bottoms Tank Release
	NRF-83	ECF Hot Cells Release Area

(1) NRF-78 was not assigned

The nine OUs at NRF were identified such that each OU contains one or more sites that have similar releases and involve the same type of CERCLA investigation. OUs 8-01, 02, 03, and 04 were Track 1 investigation sites. OUs 8-05, 8-06, and 8-09 were Track 2 investigation sites. OUs 8-07 and 8-08 were RI/FS units. Each site was investigated prior to the NRF Comprehensive RI/FS with the exception of the OU 8-08 sites and two newly identified sites. The OU 8-08 sites were investigated as part of the NRF Comprehensive RI/FS. The two new sites were investigated after the Comprehensive RI/FS using Track 1 investigations.

2.3 Summary of Past CERCLA Decisions

Thirteen of the 87 sites at NRF were evaluated prior to the FFA/CO under the COCA and were not part of an OU. These 13 sites were identified as no action sites in the FFA/CO.

In September 1994, a Record of Decision (ROD) was issued for ten sites in OUs 8-05 and 8-06, Landfill Areas, and OU 8-07, Exterior Industrial Waste Ditch. OUs 8-05 and 8-06 consist of nine sites and OU 8-07 is a single site. The decision for six sites in OUs 8-05 and 8-06 (NRF-35, 36, 48, 49, 50, and 59) and OU 8-07 was no action. The selected remedy for NRF-01, 51, and 53 within OUs 8-05 and 8-06 was the presumptive remedy for CERCLA municipal landfill sites, which consisted of containment of landfill contents with an engineered cover and monitoring of soil gas and groundwater.

2.4 Summary of Past CERCLA Response Actions

The construction of landfill covers for NRF-01, 51, and 53, as discussed above, were completed in September 1996. Seven rounds of soil gas and groundwater samples have been collected. The soil gas and groundwater samples are collected quarterly.

Two small removal actions were performed at sites NRF-20, A1W Acid Spill Area, and NRF-22, A1W Painting Locker French Drain. Soil contaminated with lead was removed from NRF-20 in August 1994 and sediment contaminated with various heavy metals was removed from NRF-22 in September 1994. NRF-22 was filled in with concrete eliminating any potential exposure pathway. NRF-20 and NRF-22 are part of OU 8-03.

2.5 Scope and Role of the NRF Comprehensive RI/FS

Eight of the nine operable units had been investigated prior to the NRF Comprehensive RI/FS. OU 8-08 represented the last OU to be investigated. The FFA/CO Action Plan describes OU 8-08 as the WAG 8 (NRF) Comprehensive RI/FS. OU 8-08 also included 18 potential radiological sites that were not assessed in any previous OU. The primary purposes of the NRF Comprehensive RI/FS were as follows: (1) investigate the 18 radiological OU 8-08 sites, which were not previously assessed; (2) evaluate the cumulative, or additive, effects of all sites at NRF on human health and the environment; and (3) address the contamination associated with those sites that had unacceptable, or potentially unacceptable, risks, which were identified as sites of concern.

OU 8-08 includes 18 sites that were not previously investigated under other OUs. These sites were grouped under OU 8-08 because of similar constituents, release mechanisms, and migration paths. The OU 8-08 sites represent areas where past controlled releases of low-level radioactive water were discharged and areas where inadvertent releases to the environment occurred because of leaks from corroded piping, leaks in underground concrete basins, surface releases, and cross-contamination of non-radiological systems with radiological systems.

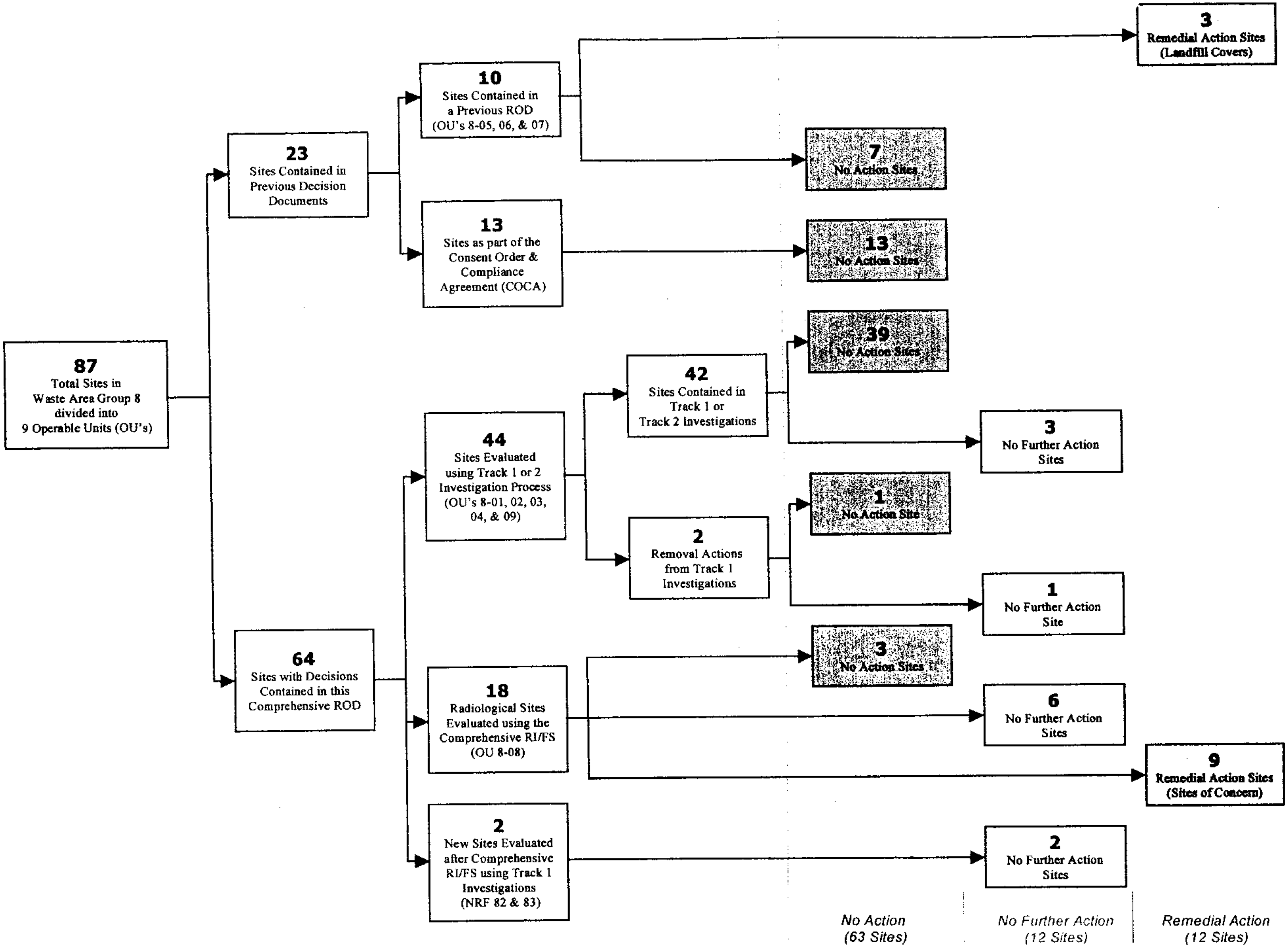

Figure 2. Synopsis of CERCLA Sites at NRF

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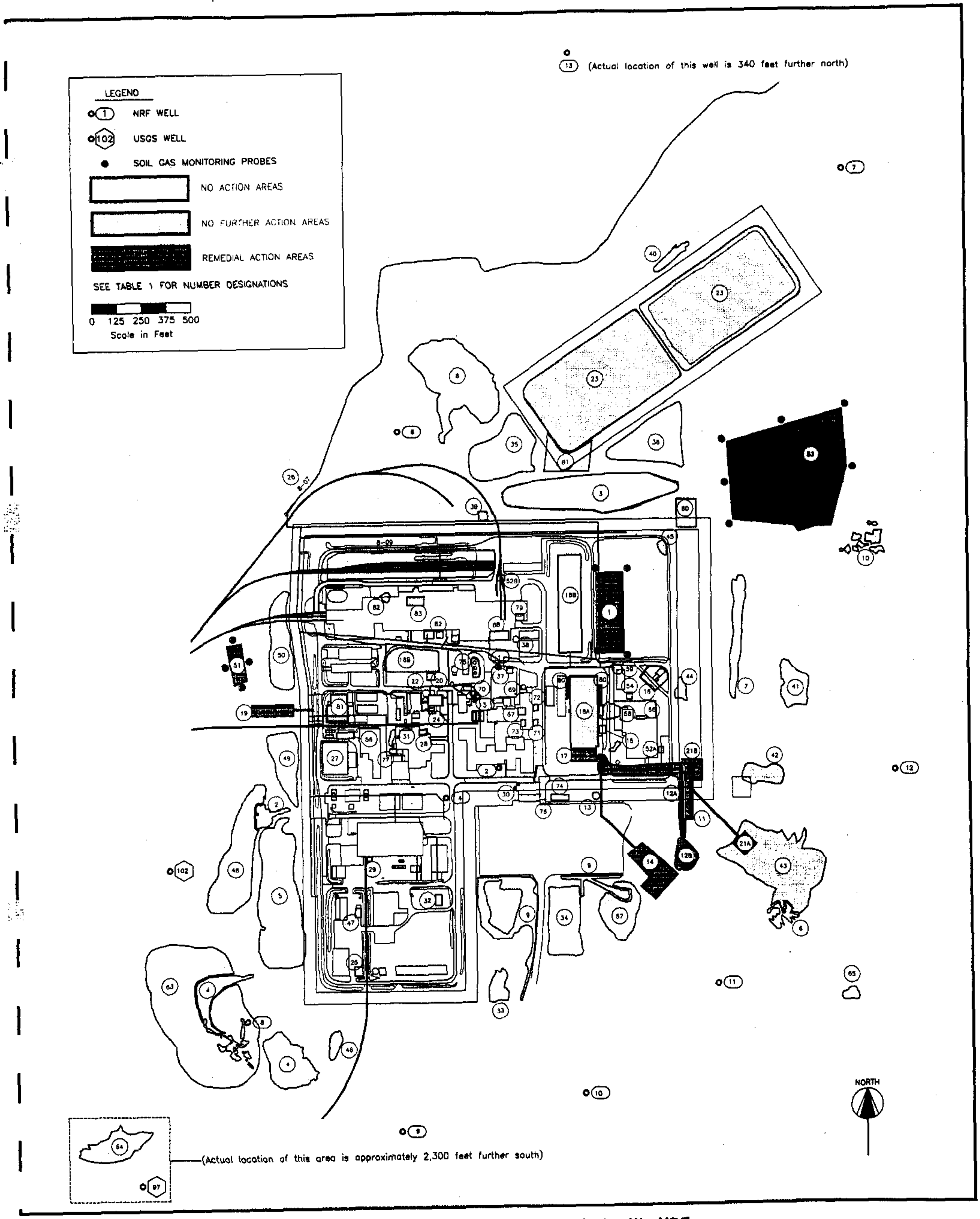

Figure 3. CERCLA Sites Associated with NRF

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The primary purpose of the radiological site assessments in OU 8-08 was to evaluate potential human health risks present at each site through various exposure pathways. Media which could create potential exposure pathways included soil, air, and groundwater. Contaminants of potential concern were determined based on risks from exposure pathways such as ingestion of soil or groundwater and direct exposure to radionuclides. Scenarios for current and future workers and future residents were considered.

The cumulative, or additive, assessment associated with the NRF Comprehensive RI/FS addressed the risks posed to human health and the environment from all identified NRF sites including the radiological areas in OU 8-08. The comprehensive assessment included reviewing all past site investigations. Sites were screened based on the presence of a contaminant source at the site. Contaminants of potential concern (COPCs) were identified and exposure pathways that could result in a cumulative risk were determined. Exposure pathways were limited to air and groundwater exposure routes, since soil exposure routes were generally site specific and not cumulative. The comprehensive assessment also included an ecological assessment to evaluate potential impacts to ecological receptors.

2.6 Purpose of this Record of Decision

This ROD addresses 64 of the 87 sites identified at NRF. (No action determinations were made for 13 sites identified in the FFA/CO. A previous ROD addressed ten sites in OUs 8-05, 8-06, and 8-07.) The Comprehensive RI/FS included 85 sites in the comprehensive cumulative risk assessment; two new sites (NRF-82 and -83) were identified after the RI/FS, and were determined to have no effect on the cumulative risk. The NRF Comprehensive RI/FS also concluded that the remedies selected for the prior 13 No Action sites, and for the ten sites addressed by a previous ROD, are protective of human health and the environment from a cumulative evaluation.

Based on evidence compiled in the NRF Comprehensive RI/FS, 55 of the 64 sites included in this ROD do not have risks or have acceptable risks to human health and the environment and require no remedial action. This includes the two new sites identified after the Comprehensive RI/FS. These 55 sites have been defined as No Action or No Further Action sites (these designations are discussed in detail in Section 8.0). Nine of the 64 sites were determined in the NRF Comprehensive RI/FS to have unacceptable or potentially unacceptable risks that must be addressed. The nine sites were all radiological areas associated with OU 8-08. These nine sites of concern were included in a screening, development, and detailed analysis of remedial action alternatives and resulted in the selection of a preferred alternative.

The remainder of this ROD summarizes the NRF Comprehensive RI/FS, the public's role in the ROD decisions, and the conclusions and decisions made to remediate the NRF site.

3.0 Summary of Site Characteristics

This section provides an overview of the site characteristics for the 64 sites being addressed by this ROD. The first part of this section discusses the characteristics of sites in OUs 8-01, 02, 03, 04, and 09. These OUs were investigated through either Track 1 or Track 2 processes prior to the NRF Comprehensive RI/FS. The second part of this section discusses OU 8-08 sites and the two new sites identified after the NRF Comprehensive RI/FS. These sites are discussed in more detail because the OU 8-08 sites were investigated as part of the NRF Comprehensive RI/FS and the new sites were not part of any other OU. (OUs 8-05, 06, and 07 are not discussed because previous decision documents have been issued for these OUs.)

A total of 44 sites are associated with OUs 8-01, 02, 03, 04, and 09. Eighteen sites are associated with OU 8-08. NRF-23, Sewage Lagoons, was originally part of OU 8-03 but was included with the OU 8-08 sites as a recommended conclusion of the site's Track 1 investigation. The two new sites were not associated with any OU.

3.1 Site Characteristics (Previous Investigations)

As stated, OUs 8-01, 02, 03, 04, and 09 were investigated prior to the NRF Comprehensive RI/FS. Each OU represents a site or group of sites with similar releases and migration pathways. The Track 1 or Track 2 investigation for each of these 44 sites resulted in a determination that enough information was available to allow a recommended decision without collecting additional data. These OUs and associated sites are briefly explained below.

3.1.1 Operable Unit 8-01

OU 8-01 consists of seven construction rubble sites. These sites contain rubble from past construction projects at NRF. Each site was evaluated in a Track 1 investigation.

NRF-03 is an excavated pit that provided clean fill for construction projects. The east end of the pit has been used for disposal of construction debris such as gravel, concrete, metal, and wood. The southeast portion of the pit was used for 3 months in 1985 for routine nonhazardous discharge water. The pit has also been used as a gunnery range for security personnel. Soil sampling showed only slightly elevated amounts of metals. The risk was estimated to be low based on the Track 1 evaluation.

NRF-06, 08, 33, 41, and 63 are rubble piles from past construction projects. The rubble piles consist primarily of soil, concrete, metal, and wood. No hazardous source is present.

NRF-40 is a soil pile from an expansion project to enlarge the current sewage lagoons. No hazardous source is present.

3.1.2 Operable Unit 8-02

OU 8-02 consists of 12 miscellaneous sites that were initially designated as Track 1 low priority sites. Each site was evaluated in a Track 1 investigation.

NRF-09 is comprised of three parking lot runoff trenches that allow water from spring thaws and heavy rainfall to drain from the parking lot. Soil sampling showed elevated amounts of lead and silver; however, the risk was estimated to be low based on the Track 1 evaluation.

NRF-37 is the former location of a temporary painting booth and storage area. The area was used from approximately 1963 to 1970. Soil sampling showed no detectable solvents or elevated amounts of metals, therefore, it was determined that no hazardous source is present.

NRF-38 is a precast manhole that received steam condensate from the site steam system. The condensate would evaporate or infiltrate into the soil. The manhole was likely used from 1958 to the 1980s. No hazardous source is present.

NRF-42 is the location of a former temporary sewage pond used in the 1950s. There is no evidence that a hazardous source exists at the site, but elevated amounts of metal, semi-volatile organic, and low-level radionuclide contaminants may be present based on sampling performed in the current sewage lagoons. Based on groundwater sample results and using average concentration data from the current sewage lagoons, this site does not represent a significant groundwater threat. The site is currently covered with a 10 foot layer of soil, thus limiting ingestion or direct contact with any contaminants, if present. Based on current conditions (i.e., 10 foot soil cover), the risk was estimated to be low based on the Track 1 evaluation.

NRF-52A, 52B, and 47 represent three locations of a lead casting and storage building. NRF-52A and 52B consist of two former locations where the soil was disturbed during past construction activities after the building was relocated. Soil samples collected near the original building location (NRF-52A) showed elevated levels of lead; however, the levels were still below the EPA recommended screening level for lead cleanup of 400 ppm. The risk for the original building location was estimated to be low based on the Track 1 evaluation. The building was moved in 1956. There was no evidence of elevated lead levels at this second location (NRF-52B). No hazardous source is present at this second building location. The building was again moved in 1982 to its current location (NRF-47). Although the building is no longer used for lead casting, samples collected from the current building location showed the building siding and drainage system did not have elevated lead levels; thus, no hazardous source was determined to be present.

NRF-54 is a steam boiler blowdown pit that was used for several years in the 1950s. The pit has reinforced concrete walls and a dirt floor. The condition of the pit is not known since the pit and access to the pit are presently covered by grass. The pit received water from blowdown of the boilers to prevent scale buildup in the system. No hazardous source is present.

NRF-55 consists of 17 french drains located around NRF. Eleven of the drains are used for steam condensate, five for storm water, and one receives water from occasional washing of vehicles. The french drains are gravel filled excavations to promote infiltration. These drains would not have received hazardous constituents, and therefore were determined to not contain a hazardous source.

NRF-61 is a former location of a radioactive material storage and laydown area that was used from 1954 to 1960. Soil sampling showed detectable amounts of cesium-137. The risk assessment assumed an institutional control period for the future residential scenario. The risk was estimated to be low based on the Track 1 evaluation.

NRF-64 is a gravel pit that has been used as a construction rubble pile. The rubble pile consists of concrete, metal, wood, and asphalt. A piece of asbestos was found at the site in 1989. A burn pile exists near the gravel pit and the ground appears stained with petroleum hydrocarbons. It is hypothesized that petroleum products were used to facilitate burning combustible waste. Soil sampling showed elevated total petroleum hydrocarbons. The risk was estimated to be low based on the Track 1 evaluation.

NRF-68 is an area that has been used for vehicle parking and construction pipe staging and cutting operations. This site was erroneously titled a "corrosion" area. Soil sampling showed detectable total petroleum hydrocarbons in the area. Small amounts of chlorobenzene were also detected in the soil. The risk was estimated to be low based on the Track 1 evaluation.

3.1.3 Operable Unit 8-03

OU 8-03 consists of eight miscellaneous sites that were initially designated as Track 1 high priority sites. Each site was evaluated in a Track 1 investigation.

NRF-10 is an area where sandblast grit from paint removal operations in the 1950s was deposited. The sandblast grit was removed in 1990. Verification sampling performed in 1991 showed elevated levels of several metals in the soil. Arsenic, chromium, and lead were detected at concentrations above background levels. A Track 1 risk assessment was performed that calculated risk-based soil concentrations for the residential and occupational scenarios. Although chromium and arsenic were detected in individual samples above risk-based soil concentrations, the risk assessment used very conservative estimates and a risk management decision was made that actual risks are acceptable.

NRF-15 and 20 are acid spill areas. Elevated levels of metals are present at each site. NRF-20 included lead contaminated soil above the EPA recommended screening level for lead cleanup. A soil removal action was performed at NRF-20 after receiving public comment on the proposed action. The only contaminants remaining at elevated levels after the removal action are mercury and lead (which is now below the screening level goal of 400 ppm). Sampling at NRF-15 showed elevated levels of chromium, lead, mercury, and nickel. The concentrations of contaminants at both sites were determined to be below risk-based concentrations. A risk assessment for each site estimated risks to be low based on the Track 1 evaluations.

NRF-18A and NRF-18B are the S1W Spray Ponds, A1W Cooling Tower, and portions of the fire protection system, and were originally designated as one site, NRF-18. At one time, a chromium based corrosion inhibitor was used in the water. The spray ponds are large concrete structures that contained cooling water for S1W plant operations. The A1W Cooling Tower served a similar function for the A1W prototype plant. Leakage and overspray from the ponds, tower, and fire protection system caused elevated chromium concentration in the surrounding soil. The Track 1 risk assessment assumed the spray ponds would remain in place, limiting exposure to the soil below the basins if any contamination was present. The resulting risk assessment estimated a low risk based on the Track 1 evaluation, but additional evaluation of NRF-18 in the NRF Comprehensive RI/FS concerning the groundwater pathway was considered appropriate.

The A1W Cooling Tower was demolished in 1995. In 1997, a decision was made to demolish the S1W Spray Pond #2. Subsequent to the Comprehensive RI/FS, NRF-18 was split into two sites: NRF-18A, S1W Spray Pond #1, and portions of the fire protection system; and NRF-18B, S1W Spray Pond #2 and A1W Cooling Tower. Additional data was collected at Spray Pond #2 after the NRF Comprehensive RI/FS in preparation of demolishing the spray pond. Twenty-four boreholes drilled through the bottom of the spray pond and twenty boreholes outside the perimeter of the spray pond were used to collect additional samples. Sample results showed slightly elevated amounts of chromium. The risk associated with Spray Pond #2 was determined to be low with much less uncertainty than the initial assessment because of the additional data. Spray Pond #1 was not included in this evaluation since no additional data were collected from Spray Pond #1 and, therefore, Spray Pond #1 was given a separate site designation (NRF-18A).

NRF-22 is the location of a former french drain that may have received paints, solvents, and possibly mercury. A removal action was performed after receiving public comment on the proposed action. Sampling performed after the removal action showed elevated levels of lead and mercury remained. The excavated hole was 12 feet deep and was grouted to the surface eliminating all exposure pathways. The risk assessment after the removal action estimated the risk to be low based on the Track 1 evaluation. Although no exposure route is present, a source remains at the site.

NRF-45 is the former location of an incinerator used to burn outdated documents. The incinerator was used at this location from 1985 to 1992. Barium, silver, and zinc were detected at elevated levels during sampling of the ash from the incinerator. The concentrations were determined to be below risk-based concentrations for the occupational and residential scenarios. The risk for the site was estimated to be low based on the Track 1 evaluation.

NRF-56 is a former location of a pipe degreasing and pickling facility used between 1957 and 1961. The facility was replaced with a railroad car shed which was used as a pipe fitter and welder training shop and is currently a records storage building. The original facility was likely completely removed when the railroad car shed was placed at this location. No hazardous source is present.

3.1.4 Operable Unit 8-04

OU 8-04 consists of sixteen sites where spills, primarily petroleum products, have occurred. Each site was evaluated in a Track 1 investigation.

NRF-28, 29, 31, 58, 65, 69, 70, 71, 72, 74, 75, 76, and 77 represent sites of past petroleum product releases. Most of the sites were oil release areas with the exception of NRF-69 (diesel) and NRF-71 (gasoline). These spill areas were generally cleaned up, but some residual contamination exists. The contaminants of concern include polychlorinated biphenyls (PCBs), total petroleum hydrocarbons, benzene, toluene, ethylbenzene, and xylene. Each contaminant was determined to be below risk-based concentrations. A risk assessment for each site estimated the risk to be low based on the Track 1 evaluations.

NRF-44 is an area where wastewater was discharged between 1954 and 1959. The discharges included surface water runoff, steam condensate, cooling water, and water from an oil-water separator. No hazardous source is present.

NRF-62 is the location of a past nitric acid spill. Around 1960, 2,460 gallons of acid was spilled. The area has since been disturbed and covered by ECF expansion construction activity. No remaining hazardous source is present.

NRF-73 is a former varnish tank. The varnish tank was used from 1970 to 1980 and was removed in 1991. Xylene was the primary component of the varnish. There was no evidence of tank leakage when the tank was removed in 1991. No hazardous source is present.

3.1.5 Operable Unit 8-09

OU 8-09 consists of the interior industrial waste ditch system. The interior waste ditch system is comprised of a network of culverts, pipes, and uncovered drainage ditches with a combined length of 23,000 feet. The system collected discharges from prototype operations, support operational activities, and storm water. Various modifications to the ditch system have been made throughout the years. The ditch may have received small amounts of hazardous constituents from cooling systems, photographic operations, and laboratory operations between 1953 and 1985. No hazardous constituents have been discharged since 1985. Contaminants of concern included various metals, organics, and radionuclides (cesium-137 and cobalt-60). A Track 2 assessment was performed on this unit. The calculated risks were within the target risk range and are considered by the agencies to be acceptable.

3.2 Site Characteristics (Operable Unit 8-08 Sites)

OU 8-08 sites were investigated as part of the NRF Comprehensive RI/FS. OU 8-08 included several radiological areas and was the last OU investigated. The 18 sites associated with OU 8-08 are discussed in more detail below. The investigation of the radiological sites in OU 8-08 was one of the primary purposes of the NRF Comprehensive RI/FS.

3.2.1 Background

Low-level radioactive effluent, primarily water with small amounts of radioactivity, was generated by each prototype facility as a result of past operations. Between June 1953 and April 1979, this low-level radioactive effluent was discharged to several leaching beds in accordance with established regulations at the time. These leaching beds are also referred to as leaching pits, ponds, lagoons, basins, or drainfields. These discharges were discontinued in 1979 when a water reuse system was established.

Beginning in 1953, low-level radioactive effluent from the S1W prototype was sent to a drainfield known as the S1W Tile Drainfield (NRF-11). This drainfield was also likely used for sewage discharges. In 1955, the sewage system and radioactive system were separated. NRF-11 was no longer used and radioactive effluent went to an underground perforated pipe drainfield (NRF-12A). Around 1957, a pit was dug at the end of the drainfield to allow the water to pond. The pit is known as the S1W Leaching Pit (NRF-12B).

A special basin or pit was constructed in 1956 for a one-time discharge of radioactive effluent that contained some oil. This basin was referred to as the S1W Temporary Leaching Pit (NRF-13). The pit was used to prevent the drainfields from receiving oily effluent thereby reducing their efficiency. The temporary pit was filled in with the soil immediately after the one-time discharge.

A1W began operation in 1958, with ECF beginning shortly thereafter. The A1W Leaching Bed (NRF-19) was constructed on the west side of NRF. The bed received effluent from A1W and ECF. The leaching bed was used sporadically through 1972.

In 1960, a new leaching bed known as the S1W Leaching Bed (NRF-14) was constructed south of the S1W prototype to receive S1W prototype effluents. This bed was a ponding area to allow infiltration of liquid into the soil. A second pond was constructed adjacent to the first in 1963. These ponds primarily received effluent from S1W, but also received effluent from the other facilities (S5G, A1W, and ECF). The last discharge to the leaching beds was in 1979.

Most of the effluent associated with the S1W discharge areas (NRF-11, NRF-12B, and NRF-14) was stored in the S1W Retention Basins (NRF-17) prior to final discharge to the areas. The basins were constructed of concrete and were used from 1953 to 1972.

Approximately 417,000,000 gallons, containing 345.41 curies, were discharged to the various drainfields, pits, and beds at NRF between 1953 and 1979. Table 2 summarizes the curies and gallons released to each site. Table 3 gives a summary by year of the curies and gallons released to all the sites.

In addition to the controlled releases of low-level radioactive liquid, there have been occurrences of inadvertent releases to the environment because of leaks from underground piping (NRF-80) and concrete basins (NRF-17 and 79), surface releases (NRF-16, 66, and 81), and cross-contamination of non-radiological systems with radiological systems (NRF-02, 21A, 21B, 23, and 43). In most cases, these releases are small compared to the controlled discharges.

One site was used for a one-time sludge disposal area (NRF-32). This site represents the only site where potentially radioactive material (sludge) other than water may have been deposited.

Table 2. Total Controlled Discharges (gallons and curies) to Radiological Areas (1953-1979)

Unit	Volume (gallons)	Quantity (curies)[a]
NRF-11	17,500,000	5.33
NRF-12	64,102,650	67.861
NRF-13	28,000	0.003
NRF-14	249,809,113	131.35
NRF-19	85,500,310	140.866
Totals	416,940,073	345.41

(a) Based on discharge records from 1960 to 1979 to the S1W Leaching Beds (NRF-14), those radionuclides individually representing greater than 5% of the curie content include cobalt-60 (33%), tritium (28%), and cesium-137 (7.6%). Discharges to NRF-11 and NRF-12 would be similar to NRF-14. The discharge to NRF-13 was primarily strontium-90. Based on discharge records to the A1W Leaching Bed (NRF-19), those radionuclides individually representing greater than 5% of the curie content include tritium (54%), cobalt-60 (15%), and cesium-137 (5.8%).

The vast majority of the discharges to the radiological areas were water with small amounts of radioactivity. Metal and organic constituents were likely present in very small quantities. The metal and organic constituents would have been from processes associated with the prototype plants and ECF. These processes included radiochemical laboratory operations, component decontamination procedures, bilge drainage, oil-water separation, and decontamination showers and sinks.

Radionuclides of concern are primarily the longer-lived radionuclides from testing and operation of prototype nuclear reactors or from spent fuel examinations. Most of the radionuclides with a radioactive half-life less than five years would have naturally decayed to almost undetectable levels by today for any releases between 1953 and 1979. The primary radionuclides with half-lives greater than five years released at NRF are cesium-137, cobalt-60, strontium-90, and tritium. Tritium, which was part of the water molecules in the effluent, would have migrated or evaporated with the water. Tritium would not be expected in the soil near the discharge areas today, since water associated with the effluent is no longer present. Cesium-137 and strontium-90, with half-lives near 30 years, and cobalt-60, with a half-life slightly greater than 5 years, would be the primary radionuclides of concern present in the soil today.

3.2.2 OU 8-08 Site Assessments

Eighteen sites were identified as radiological areas requiring an individual assessment in the NRF Comprehensive RI/FS. The assessment included reviewing past historical information and past sample results. An initial list of contaminants of potential concern (COPCs) was established based on the discharges to the site and past sample data. This data included early monitoring data and characterization sample data collected between 1990 and 1992. The preliminary list of COPCs was compared to risk-based screening levels. These screening levels are concentrations resulting in an estimated increased cancer risk of 1 in 10,000,000 (1E-07) or a hazard quotient of 0.1. The development of risk-based screening levels is discussed in Section 4.1.2.1. Cancer risks and hazard quotients are discussed in more detail in Section 4.0. A conservative approach was used to establish the initial list of COPCs. Maximum contaminant levels from each site were used for screening purposes. Early monitoring data helped identify COPCs and the potential extent of contamination at some locations. The characterization data

Table 3. Yearly Controlled Radiological Discharges to Radiological Areas (NRF-11, 12, 13, 14, 19)

Year	Volume (gallons)	Quantity (curies)
1953	2,500,000	0.08
1954	10,000,000	2.25
1955	10,000,000	6.0
1956	10,928,000	3.467
1957	11,970,000	5.482
1958	15,260,000	31.29
1959	18,745,000	8.68
1960	24,373,000	31.104
1961	24,552,650	23.729
1962	28,118,770	40.893
1963	27,291,200	58.911
1964	27,328,598	32.4
1965	33,115,417	23.65
1966	36,904,836	18.49
1967	35,372,638	8.854
1968	37,987,954	13.453
1969	28,529,781	15.875
1970	20,399,951	12.263
1971	10,680,479	3.720
1972	1,232,098	0.696
1973	525,174	0.5165
1974	440,111	1.588
1975	276,852	1.002
1976	162,571	0.423
1977	194,298	0.303
1978	44,830	0.260
1979	5,865	0.028
Totals	416,940,073	345.408

from 1990-92 typically had the data quality currently required by the EPA for use in risk assessments.

The historical evaluation of the sites provided the basis for the remedial investigation sampling plans. The sampling served several different purposes depending on the area in which the sampling was being performed. In some cases, the determination of a contaminant source and the extent of contamination were the goals of the sampling. This allowed a risk assessment evaluation to be performed with a higher degree of certainty. For other areas, it was important to determine the potential volume of soil that may require a remedial action. In these areas, the nature of the contaminants was known from previous sampling, but a more definitive boundary was needed to provide accurate estimates of potential soil volumes requiring remedial actions. Enough past information was available for some areas that additional sampling during the remedial investigation was not required. After evaluating the historical and remedial investigation sample results, a final list of COPCs was established. These COPCs were used for risk assessments performed as part of the NRF Comprehensive RI/FS and are discussed in Section 4.0.

The following sections describe the characteristics associated with each of the OU 8-08 sites.

3.2.2.1 Old Ditch Surge Pond (NRF-02)

The surge pond area (NRF-02) was excavated in late 1958 or early 1959 as a gravel or soil pit for construction projects at NRF. The pit was approximately 110 feet in diameter and 12 feet deep. The pit was later connected to a drainage ditch and was likely used as a storm water drainage area for heavy precipitation events. Around 1963, the pit and drainage ditch were connected to the NRF interior waste ditch system. The pit, which then acted as a pooling place for water, was used as either an overflow or settling area. The pond area and a portion of the ditch were isolated from the waste ditch system in 1985 when portions of the ditch system were replaced with underground, corrugated piping.

This area was not included in the remedial investigation sampling. Surface soil samples have been collected in the area from 1986 to 1993. The samples were analyzed for cobalt-60 and cesium-137. Cobalt-60 was detected at a maximum activity of 11.28 picocuries per gram (pCi/g) in 1991 and cesium-137 was detected at a maximum activity of 4.7 pCi/g in 1992. Characterization sampling was performed at the pond in 1991. Samples were collected from a borehole in the middle of the ditch to a depth of three feet where the basalt was encountered. Samples were analyzed for pesticides, PCBs, organics and metals. The only COPCs detected were arsenic at 8.5 parts per million (ppm) and chromium at 90.2 ppm, which were both above background levels.

The extent of the contamination is limited to the pond area and attached ditch. The contamination is limited to the upper two feet of soil.

3.2.2.2 S1W Tile Drainfield and L-shaped Sump (NRF-11)

NRF-11 consists of a below-surface sump and various underground, perforated drainfield pipes downstream of the sump. The drainfield was likely used between 1953 and 1955 for sewage and radioactive liquid discharges. The drainfield is approximately 36 feet wide by 200 feet long and consists of four lateral perforated pipes buried six to ten feet deep. The drainfield was connected to the sump, which is a L-shaped concrete structure. Each leg of the sump is 11 feet long and three feet wide with a depth of 12-1/2 feet. The sump was isolated from the drainfield in 1955 and was used until 1960 as part of the sewage system.

An estimated 17,500,000 gallons of radioactive effluent containing 5.33 curies of radioactivity were discharged to the drainfield via the sump. Although discharge records during the timeframe NRF-11 was used did not specify radionuclides, discharges to the drainfield would be similar to later discharges to other facilities. Discharge records from 1960 to 1979 show cobalt-60 (33%), tritium (28%), and cesium-137 (7.6%) were the primary radionuclides released. By 1996, the radioactivity would have decayed to an estimated 0.33 curies. Cobalt-60, with a half-life of only five years, would have decayed to very small levels after 40 years. Tritium would have leached or evaporated with the water. Small amounts of chemicals and oil in the effluent may have been released to the drainfield.

The source of contamination around the L-shaped sump was the same as the drainfield. The sump may have leaked to surrounding soils. In addition, the sump was used until 1960 as part of the sewage system.

Characterization sampling efforts in 1991 collected samples to a depth of 22 feet from a borehole in the drainfield area. The samples were analyzed for pesticides, PCBs, organics, and metals. The only COPCs detected were arsenic (maximum of 7.6 ppm, which is slightly above background), dieldrin (a pesticide at 0.008 ppm in a single sample), cobalt-60 (maximum of 0.07 pCi/g), and cesium-137 (maximum of 0.3 pCi/g, which is actually below surficial soil background levels).

During the remedial investigation, attempts were made to locate the drainfield piping using geophysical methods, but these attempts were inconclusive. Samples were collected from 11 boreholes at the drainfield and around the sump. Due to uncertainties in the location of the drainfield piping, the samples may not have been located adjacent to the piping where contamination is suspected. Samples were collected to a depth of 12 feet and analyzed for radionuclides, organics, PCBs, pesticides, and metals. The only COPC detected in the drainfield area was cobalt-60 at 2.7 pCi/g in one borehole from an eight foot depth. Several COPCs were detected around the sump. Arsenic (maximum of 8.92 ppm at an eight foot depth) was the only non-radiological COPC detected. Americium-241 (0.42 pCi/g in a single sample at a 12 foot depth), americium-243 (0.5 pCi/g in a single sample at a 12 foot depth), cesium-137 (maximum of 45.98 pCi/g at an eight foot depth), cobalt-60 (maximum of 1.17 pCi/g at a 12 foot depth), manganese-54 (0.06 pCi/g in a single sample at a eight foot depth), and plutonium-244 (0.09 pCi/g in a single sample at a 12 foot depth) were the radiological COPCs detected.

The remedial investigation sampling indicates that any significant contamination at the drainfield is likely confined to a small volume of soil near the underground pipes. The extent of contamination is estimated to be an area one foot around the perimeter of the underground piping, which is six to ten feet deep. The contamination around the sump is expected to be within three feet of the sump walls. Past sampling from within the L-shaped sump confirm the presence of cesium-137 above risk-based levels at this site. Based on historical and process knowledge, uncertainty regarding the actual location of the drainfield piping, and sample results from the L-shaped sump located upstream of the drainfield, the agencies have made the presumption that soils at the drainfield are contaminated with cesium-137 above risk-based levels.

3.2.2.3 Underground Piping to Leaching Pit (NRF-12A)

In 1955, a drainfield was constructed south of S1W, adjacent to NRF-11 (S1W Tile Drainfield). The drainfield was an underground, perforated pipe that ran from a manhole to a location 400 feet south of the manhole. The pipe depth was eight feet. This drainfield was used for radiological discharges after NRF-11 was no longer used. In 1957, a pit was dug at the end of the underground pipe to allow pooling of the water. The pit is known as the S1W Leaching Pit (NRF-12B). The drainfield was used for discharges until 1960. NRF-12A includes the manhole and the underground piping from the S1W Retention Basins (NRF-17) to the manhole and from the manhole to the leaching pit.

An estimated 64,100,000 gallons of radioactive effluent containing 67.9 curies of radioactivity were discharged to the drainfield via the manhole. Cobalt-60 and cesium-137 were likely the primary radionuclides released. Most of the cobalt-60 will have decayed away leaving cesium-137 as the primary radionuclide of concern.

Samples were collected from 18 boreholes to a depth of 10 feet during pre-RI/FS sampling in October 1995 along the underground pipe from the retention basins to the manhole. Samples were analyzed for radionuclides and metals. The COPCs detected were chromium (maximum of 110 ppm at an eight foot depth), cesium-137 (maximum of 7,204 pCi/g at an eight foot depth), cobalt-60 (maximum of 70.8 pCi/g at a six foot depth), nickel-63 (maximum of 75.15 pCi/g at an eight foot depth), strontium-90 (maximum of 28.28 pCi/g at an eight foot depth), and plutonium-239 (a single sample of 0.0728 pCi/g at an eight foot depth).

The remedial investigation sampling included five boreholes along the underground pipe from the retention basins to the manhole, three boreholes around the manhole, and five boreholes along the underground, perforated pipe leading from the manhole. Samples were analyzed for PCBs, metals, and radionuclides. The following COPCs were detected: chromium (maximum of 97 ppm at a ten foot depth), mercury (maximum of 6.5 ppm at an eight foot depth), americium-241 (maximum of 0.60 pCi/g at a six foot depth), carbon-14 (maximum of 8.7 pCi/g at an eight foot depth), cesium-137 (maximum of 7,323 pCi/g at an eight foot depth), cobalt-60 (maximum of 104.9 pCi/g at an eight foot depth), nickel-63 (maximum of 329.06 pCi/g at an eight foot depth), plutonium-238 (maximum of 0.60 pCi/g at an eight foot depth), plutonium-239 (maximum of 0.20 pCi/g at an eight foot depth), plutonium-244 (maximum of 0.24 pCi/g at an eight foot depth), and strontium-90 (maximum of 35.35 pCi/g at an eight foot depth).

Most of the contamination at NRF-12A is within three to five feet of the underground pipe. Contamination exists along the entire 400 foot length of underground, perforated pipe from the manhole to the leaching pit location. Contamination is also present along approximately one-half the 500 foot length of underground pipe from the retention basins to the manhole. The contaminants are primarily present between the six and ten foot depth.

3.2.2.4 S1W Leaching Pit (NRF-12B)

In 1957, a pit was dug at the end of the underground, perforated pipe drainfield (NRF-12A). This pit was known as the S1W Leaching Pit (NRF-12B). The pit was used from 1957 until 1961 when it was filled in with soil. The pit was approximately eight feet wide, eight to ten feet deep, and 50 feet long. The releases to the pit were discussed in the previous section. Cesium-137 and cobalt-60 were the primary contaminants released. An asphalt cover was placed over the leaching pit location in 1978 and is present at the site today.

Historical sampling has shown elevated levels of radionuclides in the area of the leaching pit. Although the historical sampling did not meet modern data quality requirements for use in risk assessments, it did provide valuable information on the location of the pit and types of contaminants present. Characterization samples were collected in 1991 from a borehole near the leaching pit. Samples were collected to a depth of 18 feet and were analyzed for metals, radionuclides, organics, pesticides and PCBs. The COPCs detected were arsenic (maximum of 100 ppm at a three foot depth), lead (maximum of 1,140 ppm at a three foot depth), cesium-137 (maximum of 1.09 pCi/g at a three foot depth) and cobalt-60 (maximum of 0.11 pCi/g at a 15 foot depth). Because of the low level of radionuclides detected, the borehole was probably outside the boundary of the leaching pit.

The leaching pit was evaluated in the NRF Comprehensive RI/FS with the S1W Leaching Beds (NRF-14) because the pit is adjacent to NRF-14. The sampling plan identified the leaching beds and leaching pit as one sampling area, since they had similar discharges, were located next to each other, and had the same sampling goals. The purpose of the RI/FS sampling was to provide enough data to estimate the volume and level of contamination of the soil outside the known discharge areas.

Samples were collected from ten boreholes outside the leaching beds and leaching pit down to a depth of 20 feet. Samples were also collected from a borehole that was estimated to be over the leaching pit. From the boreholes at or near the leaching pit the following COPCs were detected: cesium-137 (maximum of 1,600 pCi/g at a 14 foot depth), cobalt-60 (maximum of 9.2 pCi/g at a 14 foot depth), plutonium-239 (maximum of 0.13 pCi/g at a 14 foot depth), and strontium-90 (maximum of 37.3 pCi/g at a 14 foot depth). Carbon-14 may also be present because it was detected in samples collected upstream of the leaching pit (NRF-12A).

The contamination at NRF-12B is primarily at the location of the former pit, which was estimated to be eight feet wide and 50 feet long. The radionuclide contamination was generally found at the 14 foot depth. Some metals were detected at a three foot depth during characterization sampling in 1991, but this is suspected to be from soil placed over the area after it was no longer used.

3.2.2.5 S1W Temporary Leaching Pit (NRF-13)

A temporary pit (NRF-13) was dug in 1956 for the one-time discharge of 28,000 gallons of oily contaminated radioactive liquid. The pit was used to prevent other radioactive discharge areas from receiving oily effluent and reducing their efficiency. The pit was 15 feet in diameter and 18 feet deep. The 28,000 gallons of effluent contained 0.003 curie of radioactivity. The only identified radionuclide was a maximum of 0.00024 curie of strontium-90. Other suspected radionuclides include cobalt-60 and cesium-137. The pit was used for the one-time discharge and then was filled in with the excavated soil.

Characterization sampling was performed in the area in 1991. Samples were collected from the suspected location of the pit to a depth of 25 feet. Samples were analyzed for radionuclides, metals, organics, pesticides, and PCBs. The only COPCs detected at the site were arsenic (maximum of 9.3 ppm at a 13 foot depth), cesium-137 (maximum of 0.15 pCi/g at a 20 foot depth) and cobalt-60 (maximum of 0.1 pCi/g at a 15 foot depth). The cesium-137 and cobalt-60 data were near minimum detectable levels. No additional sampling was performed in this area.

The extent of contamination at NRF-13 is the 15 foot diameter of the pit with a conservatively estimated depth starting at 13 feet and ending at 23 feet below the surface.

3.2.2.6 S1W Leaching Beds (NRF-14)

The first S1W Leaching Bed was constructed in 1960. The bed was an open pond that allowed the water to evaporate or infiltrate into the ground. A second bed was constructed in 1963 adjacent to the first bed. Each bed was about 75 feet by 125 feet at the water line and was 13 to 15 feet deep. The beds originally received radioactive effluent from the S1W prototype plant and later received effluent from the S5G and A1W prototypes and ECF. The beds were used from 1960 to 1979 and received approximately 250,000,000 gallons of water containing 131 curies of radioactivity. The primary radionuclides released were cesium-137, cobalt-60, and tritium. Tritium, which exhibits similar properties as water, would not be expected in the soil today. The cobalt-60 would have decayed to much smaller levels. Small amounts of chemicals and oil may have been released to the leaching beds.

This site includes the underground pipe leading to the leaching beds. The pipe was known to have leaked on one occasion; however, much of the contaminated soil was excavated at that time.

Characterization sampling of the beds was performed in 1992. Samples were collected from a borehole in each bed down to the basalt layer below the beds. The basalt layer is approximately 35 feet below the surface. The samples were analyzed for radionuclides, metals, organics, PCBs, and pesticides. The following nonradiological COPCs were detected during the sampling (All depths noted are from the bottom of the beds): aroclor-1260 (a PCB at 0.245 ppm in a single sample at a three foot depth), arsenic (maximum of 18.3 ppm at a 29 foot depth), chromium (maximum of 65.1 ppm at a three foot depth), and mercury (maximum of 3.9 ppm at a three foot depth). The following radiological COPCs were detected during the sampling: americium-241 (maximum of 5.9 pCi/g at a three foot depth), cesium-137 (maximum of 2,040 pCi/g at a three foot depth), cobalt-60 (maximum of 407 pCi/g at a three foot depth), nickel-63 (maximum of 730 pCi/g at a four foot depth), plutonium-238 (maximum of 5.9 pCi/g at a three foot depth), plutonium-239 (maximum of 0.5 pCi/g at a three foot depth), and strontium-90 (maximum of 83 pCi/g at a four foot depth). The americium-241 and plutonium-238 were not distinguished from each other, and therefore, the 5.9 pCi/g represents the potential maximum for either radionuclide.

The S1W Leaching Beds were evaluated with the S1W Leaching Pit (NRF-12B) during the NRF Comprehensive RI/FS as explained in the previous section. Since the 1992 sampling sufficiently characterized the soil below the leaching beds, the purpose of the RI/FS sampling was to define the lateral extent of contamination outside the leaching beds, which would allow the estimation of soil volume contaminated above risk-based levels. Samples were collected from 10 boreholes to a depth of 20 feet adjacent to the beds and pit. Samples collected from boreholes adjacent to the beds showed very little migration of contaminants in the upper 20 feet of soil. Cobalt-60 was the only COPC detected and was detected at a maximum concentration of 1.21 pCi/g at a 14 foot depth.

Three additional boreholes were drilled to the basalt on the north, west, and south side of the leaching beds where a historic perched water layer existed above the basalt. Small amounts of contaminants were found in these boreholes. The COPCs detected in these boreholes were arsenic (maximum of 8.61 ppm at a 30 foot depth), lead (maximum of 29.5 ppm at a 30 foot depth), cobalt-60 (maximum of 1.02 pCi/g at a 25 foot depth), neptunium-237 (0.79 pCi/g in a single sample at a 30 foot depth), nickel-63 (9.67 pCi/g in a single sample at a 25 foot depth), and strontium-90 (3.37 pCi/g in a single sample at a 25 foot depth).

The extent of contamination at NRF-14 is primarily within the soil directly below the leaching beds. The borehole sampling adjacent to the leaching beds showed only small amounts of contaminants. The contaminants are primarily retained within the top four feet of the bottom of the leaching beds. Contamination significantly drops off after the four foot depth.

The sampling performed at the historic perched water area showed no residual water and only minimal contamination with no exposure pathway available because of the significant depth of the residual contamination. Neptunium-237, which was not detected in the leaching beds, was detected at a very small concentration (0.79 pCi/g) in a single sample from the former perched water zone. It was the only contaminant detected at a higher concentration in the former perched water area than in leaching bed samples.

3.2.2.7 Radiography Building Collection Tanks (NRF-16)

The radiography building was constructed in 1954, north of the S1W prototype plant. The building was originally constructed to decontaminate radioactive equipment. Various solvents were likely used in the decontamination process. Two underground tanks were used to collect the solvents after the decontamination process. In 1960, the building was converted to perform radiography to find defects in various materials. The decontamination tanks were no longer used. The tanks and associated piping were removed in 1993. The tanks were in good condition with no apparent leaks from the tanks.

Historical sampling has been done around the tank and building area. Past spills of radioactive liquid occurred in this area and were generally cleaned up at the time of the spill. The historical sampling helped determine the likely location of past spills and establish an initial list of COPCs. Characterization sampling was performed in 1990. Soil samples were collected from a borehole to a depth of 22 feet adjacent to the underground tanks. The only COPC detected above risk-based concentration was arsenic, which was detected at a maximum concentration of 9.6 ppm at the 22 foot depth.

Soil samples were collected from 20 targeted locations during the NRF Comprehensive RI/FS to evaluate potential past spills in the area. Samples were collected from the surface, one foot depth, and two foot depth. The following COPCs were detected above background and risk-based concentrations near the radiography building: arsenic (maximum of 7.64 ppm at a ten foot depth), cesium-137 (maximum of 10.8 pCi/g at the surface), cobalt-60 (maximum of 0.36 pCi/g at the surface), and uranium-235 (0.18 pCi/g in a single sample at a one foot depth). Uranium-235 is a naturally occurring radionuclide, but background levels at the INEEL are not known. Samples were also collected from a borehole adjacent to a sump located next to the building and from the sediment present in the sump. The sump, which is the lowest point near the building, is the most likely location to detect past spills. Samples were collected to a depth of ten feet, which was below the sump depth. Additional COPCs were detected in the sump sediment. They were benz(a)anthracene (0.26 ppm), benzo(a)pyrene (0.26 ppm), benzo(b)fluoranthene (0.430 ppm) and indeno(1,2,3-CD)pyrene (0.18 ppm).

The extent of contamination at NRF-16 is expected to be limited to the upper few feet of soil as a result of past surface spills. Very little contamination has been found in the subsurface soil.

3.2.2.8 S1W Retention Basins (NRF-17)

The S1W Retention Basins (NRF-17) were constructed in 1951. The basins are two concrete structures 140 feet long by 34 feet wide. The basins received radioactive effluent from the S1W prototype plant and later received effluent from the S5G and A1W prototype plants and ECF. The basins were used as a radioactive liquid storage facility prior to discharging the liquid to the discharge areas (S1W Tile Drainfield, S1W Leaching Pit, and the S1W Leaching Beds). One of the basins is known to have leaked approximately 33,000 gallons in 1971. The leak was directly below the basins.

Because of the difficulty in collecting samples below the basins, sampling was deferred until the basins are demolished under decontamination and dispositioning activities associated with the remedial action at NRF. Samples were collected during the NRF Comprehensive RI/FS adjacent to the basins where past surface soil contamination was suspected. Samples were collected from four locations to a depth of one foot. Arsenic (maximum of 17 ppm) and lead (maximum of 89 ppm) were the only constituents detected above background levels.

The extent and level of contamination below the S1W Retention Basins is unknown. However, soil sampling performed at downstream sites from the basins within the same disposal system showed an unacceptable risk for cesium-137 and strontium-90 to a potential 100-year future resident. It is also known that one of the basins leaked on at least one occasion and the leakage was capable of contaminating soils below the basins. Therefore, a presumptive decision was made that some of the soils beneath the retention basins are contaminated with cesium-137 and strontium-90 at concentrations which exceed risk-based levels.

3.2.2.9 A1W Leaching Bed (NRF-19)

The A1W Leaching Bed (NRF-19) was constructed west of NRF in 1957. The bed was not an open pond like the S1W Leaching Beds. The A1W Leaching Bed was similar to a drainfield with underground, perforated pipes distributing the liquid to an area constructed of gravel and sand. The bed was 200 feet long and 50 feet wide. The bed was used continually from 1958 to 1964 for effluent discharges from the A1W prototype and ECF. The bed was used sporadically from 1964 until 1972, when use of the bed was discontinued.

A total of 85,500,000 gallons of water containing 141 curies of radioactivity was discharged to the leaching bed. The primary contaminants released were cesium-137, cobalt-60, strontium-90, and tritium. Cobalt-60 would have decayed to much smaller levels. Tritium, which exhibits similar properties as water, would not be expected in the leaching bed today. The leaching bed may have received small quantities of chemicals and oil associated with various processes at A1W and ECF.

Characterization sampling was performed at NRF-19 in 1991-92. Samples were collected from a borehole in the center of the leaching bed. The borehole depth was ten feet where the basalt layer was encountered. Arsenic (maximum of 8.0 ppm at a nine foot depth) and chromium (maximum of 298 ppm at a five foot depth) were the only nonradiological COPCs detected. The radiological COPCs detected were americium-241 (maximum of 20 pCi/g at a five foot depth), cesium-137 (maximum of 1,390 pCi/g at a five foot depth), cobalt-60 (maximum of 129 pCi/g at a six foot depth), nickel-63 (maximum of 730 pCi/g at a five foot depth), plutonium-238 (maximum of 20 pCi/g at a five foot depth), plutonium-239 (maximum of 1.18 pCi/g at a five foot depth), strontium-90 (maximum of 750 pCi/g at a five foot depth), and uranium-234 (maximum of 4.7 pCi/g at a five foot depth). The estimated depth of the underground, perforated pipe is five feet. The americium-241 and plutonium-238 results were not distinguished from each other, and therefore, the 20 pCi/g represents the potential maximum for either radionuclide.

Sampling was performed during the NRF Comprehensive RI/FS around the perimeter of the A1W Leaching Bed. Four boreholes were drilled adjacent to the bed. The only COPCs detected above background and risk-based screening levels were carbon-14 (maximum of 6.73 pCi/g from a ten foot depth), cobalt-60 (maximum of 2.12 pCi/g from a 14 foot depth), and strontium-90 (maximum of 24.86 pCi/g from a 14 foot depth).

The RI/FS sampling also included three boreholes drilled northwest, north, and northeast of the leaching bed down to the basalt. These boreholes were in an area of a historic perched water layer. The only COPCs detected above background and risk-based concentrations in these samples were carbon-14 (3.35 pCi/g in a single sample at a ten foot depth) and cobalt-60 (maximum of 0.43 pCi/g at an 18 foot depth). Background levels for carbon-14 are unknown.

The extent of contamination at the A1W Leaching Bed is limited to the soil within and directly below the leaching bed. Very little migration of the contaminants was found. This represents an area 200 feet by 50 feet with a depth of 10 feet.

3.2.2.10 Old Sewage Basin (NRF-21A)

In 1956, a sewage basin (NRF-21A) was constructed to the southeast of NRF. The sewage basin was an open pond that was originally 72 feet by 72 feet and 11 feet deep. The basin was cross-contaminated with the radiological discharge system in 1956. The basin was enlarged in

1957 to approximately double the original length and was used until 1960. The basin has since been filled in with soil.

Soil samples were collected from a borehole in the estimated location of the basin during characterization sampling in 1991 to a depth of 20 feet. Samples were analyzed for radionuclides, metals, organics, pesticides, and PCBs. Arsenic (maximum of 8.5 ppm at a three foot depth) and n-nitrosodi-n-propylamine (0.92 ppm in a single sample at a 20 foot depth) were the only nonradiological COPCs detected above background and risk-based concentrations. Cesium-137 (maximum of 0.18 pCi/g at a one foot depth) and cobalt-60 (maximum of 0.13 pCi/g at a 20 foot depth) were the radiological COPCs detected.

Soil samples were collected during the NRF Comprehensive RI/FS from two boreholes at the basin. One borehole was near the expected discharge point, while the second borehole was near the center of the basin. Samples were collected to a depth of 14 feet and were analyzed for radionuclides, metals, and organics. No COPCs were detected in the second borehole. In the first borehole, the nonradiological COPCs detected above background and risk-based concentrations were antimony (maximum of 180 ppm at a 14 foot depth), cadmium (maximum of 13 ppm at a 14 foot depth), chromium (maximum of 1,000 ppm at a 14 foot depth), mercury (maximum of 10 ppm at a 14 foot depth), and silver (maximum of 55 ppm at a 14 foot depth). The radiological COPCs detected above risk-based concentrations were cesium-137 (maximum of 229 pCi/g at a 14 foot depth) and cobalt-60 (maximum of 2.6 pCi/g at a 14 foot depth). The 14 foot depth corresponds to the original depth of the basin and includes a three foot layer of soil that was mounded over the basin when it was filled.

Soil samples were also collected from 40 random sample locations over the basin and an adjacent area (NRF-43) that was used for a one-time pumpout of the basin. The soil over the basin was sampled because, when the basin was filled in, a three foot layer of soil was placed over the basin that likely came from the pumpout area. Samples were collected from the surface, one foot depth, and two foot depth. Samples were analyzed for cesium-137 and cobalt-60 and no detectable amounts were found at the one and two foot depths over the basin. Cesium-137 was detected at a maximum of 1.9 pCi/g at the surface.

The extent of contamination at NRF-21A is estimated to be a two foot layer of soil at the bottom of the original basin prior to the basin being elongated in 1957. The second borehole sampled during the RI/FS was in the location of the expanded basin and no COPCs were detected.

3.2.2.11 Sludge Drying Bed (NRF-21B)

The sludge drying bed (NRF-21B) was constructed in 1951 as part of the sewage system at NRF. The bed was a concrete slab that was 25 feet by 25 feet and slab was approximately five feet below surrounding ground elevation. The bed received sludge from the sewage system. The bed was suspected to have been contaminated with radionuclides when the sewage system was cross-contaminated with the radiological discharge system in 1956. The bed has since been filled in with soil to surrounding surface elevation.

The only sampling performed at NRF-21B was during the NRF Comprehensive RI/FS. Samples were collected from four boreholes at the bed down to the concrete slab. Samples were analyzed for radionuclides, metals, organics, and PCBs. The following nonradiological COPCs were detected above background and risk-based concentrations: antimony (maximum of 55 ppm), cadmium (maximum of 4 ppm), chromium (maximum of 420 ppm), mercury (maximum of 13.9 ppm), silver (maximum of 52 ppm), benzo(a)pyrene (0.1 ppm in a single sample), and benzo(b)fluoranthene (maximum of 0.19 ppm). The following radiological COPCs were detected: cesium-137 (maximum of 43.6 pCi/g), cobalt-60 (maximum of 1.06 pCi/g), and uranium-235 (0.17 pCi/g in a single sample). All the sample results above were from the four foot depth.

The extent of contamination at NRF-21B is limited to the 25 foot by 25 foot concrete slab. The depth of contamination is between four to six feet.

3.2.2.12 Sewage Lagoons (NRF-23)

The NRF Sewage Lagoons (NRF-23) are located northeast of NRF. The lagoons were constructed in 1960 and were expanded in 1972. The lagoons are open ponds measuring 425 feet by 725 feet at water level. The lagoon bottoms are clay lined. The southwest lagoon has only been used for occasional overflow from the northeast lagoon since 1984. The northeast lagoon is still in use.

Past sampling has shown organics, metals, and radionuclides present in the sediment of the lagoons. Sufficient sample results were available to calculate a 95% upper confidence limit (UCL) for most metal and radionuclide constituents. The following COPCs were detected during past sampling: arsenic (25.6 ppm, 95% UCL), cadmium (5.1 ppm, 95% UCL), chromium (571 ppm, 95% UCL), mercury (2.5 ppm, 95% UCL), silver (180 ppm, maximum concentration), benz(a)anthracene (0.22 ppm, maximum concentration), cesium-137 (3.6 pCi/g, 95% UCL), and cobalt-60 (0.39 pCi/g, 95% UCL). The cesium-137 and cobalt-60 data were from environmental monitoring sampling performed in 1994 and 1995, which is the most current reliable data available and represents randomly collected samples over the lagoon. The metal and organic data is from samples collected in 1988. The silver is shown as a maximum concentration since the 95% UCL for silver was much higher because of the wide range of silver concentrations detected during the sampling. All sample results are from the southwest lagoon although similar concentrations would be expected in the northeast lagoon.

Perched water is known to exist approximately 20 feet below the northeast sewage lagoon. The extent of this perched water zone is limited to within 50 feet of the edge of the lagoon. Other minor perched water zones were discovered at various depths, 300 to 500 feet from the lagoon. This information suggests that a stair-step migration pattern exist at the sewage lagoon. Perched water sampling has shown slightly elevated levels of nitrates and several anions (e.g., chloride) and cations (e.g., sodium) associated with the sewage lagoons. Groundwater monitoring data indicates that the sewage lagoon is the primary source of nitrate to the aquifer near NRF. Other contaminants contained within the sewage lagoon sediment appear to remain bound in those sediments.

The vertical extent of contamination present at the sewage lagoons is estimated to be 12 inches, which represents the average sediment layer thickness on the bottom of the lagoons. The horizontal extent of contamination is the area of the sediment on the bottom of the lagoons. This represents an area approximately 360 feet by 680 feet for each lagoon.

3.2.2.13 S5G Basin Sludge Disposal Bed (NRF-32)

In 1967, sludge from a cleaning effort at the S5G prototype was disposed of to an area south of S5G. The S5G hull basin at one time held water to allow simulation of sea conditions. The contaminants present in the sludge were not known and may have contained small quantities of radionuclides. The volume of sludge disposed of to the area was conservatively estimated at a maximum of 3,000 cubic feet.

Sampling was performed during the NRF Comprehensive RI/FS at this site. Samples were collected from three boreholes where the sludge was buried. Samples were analyzed for radionuclides, organics, metals, and PCBs. The only COPC detected was arsenic at a maximum concentration of 8.49 ppm from a 10 foot depth.

3.2.2.14 Seepage Basin Pumpout Area (NRF-43)

A sewage basin (NRF-21A) was pumped out to the surrounding area (NRF-43) in August 1958. The basin had been cross-contaminated with the radioactive discharge system in 1956, and therefore, the basin contents likely contained some radioactivity. The volume or amount of radioactivity released from the basin is not known. Historic sampling has shown some detectable levels of radioactivity in the pumpout area. This sampling helped determine the location of the pumpout area and identify potential COPCs.

Characterization sampling was performed in the area in 1991. Soil samples were collected to a depth of five feet and analyzed for metals, organics, radionuclides, pesticides, and PCBs. The COPCs detected above background and risk-based concentrations were arsenic (maximum of 7.8 ppm at a five foot depth) and cesium-137 (maximum of 1.08 pCi/g at a three foot depth).

Soil samples were also collected from 40 random sample locations over the basin and the pumpout area during the NRF Comprehensive RI/FS. Samples were collected from the surface, one foot depth, and two foot depth. Sufficient samples were collected and analyzed for cesium-137 that a 95% upper confidence limit for cesium-137 was calculated to be 1.31 pCi/g. Other COPCs detected above risk-based screening levels were carbon-14 (36.71 pCi/g in a single sample) and plutonium-239 (0.94 pCi/g in a single sample). This sampling showed that, where radioactivity was detected, most of the activity was in the upper two feet and only small activity levels were detected at the two foot depth.

The extent of contamination at NRF-43 is limited to the upper two feet of soil, which is a result of the one time pumpout of the sewage basin (NRF-21A). NRF-43 represents an area of approximately 97,000 square feet.

3.2.2.15 Hot Storage Pit (NRF-66)

NRF-66 was misidentified as a hot storage pit. The area was a waste tanker loading area where radioactive liquid waste was collected for processing at other INEEL facilities. Various inadvertent releases may have occurred in the tanker loading area. The releases would have been cleaned up to established standards at the time of the release. Contaminated soil was removed from the area in 1980.

Sampling was performed at NRF-66 during the NRF Comprehensive RI/FS. Soil samples were collected from 14 shallow boreholes to a two foot depth. The purpose of the sampling was to evaluate potential residual contamination in the soil from past surface spills in the area. The samples were analyzed for radionuclides. The only COPC detected above background and a risk-based concentration was cesium-137 at a maximum activity of 1.88 pCi/g.

The extent of contamination at NRF-66 is limited to a two foot depth. The area is approximately 10 foot by 45 foot.

3.2.2.16 ECF Water Pit Release (NRF-79)

A maximum one-time release of 62,500 gallons of water from ECF occurred in late 1991 and early 1992. The ECF water contained small amounts of carbon-14, cesium-137, cobalt-60, manganese-54, nickel-63, strontium-90, and tritium. A very conservative assumption was made for the risk assessment calculations discussed in Section 6.0 that the entire volume of water immediately migrated to the aquifer without any dilution and was available for consumption. No soil sampling was performed because contaminants, if present, would be 30 feet below the surface and unavailable for exposure to any receptors.

3.2.2.17 A1W/S1W Radioactive Line near BB19 (NRF-80)

During the construction of A1W, a pipe was installed from the A1W prototype to the S1W Retention Basins that allowed radioactive effluents from A1W to be sent to the S1W radioactive discharge system. The pipe was buried approximately six feet below the surface. The pipe is known to have leaked on one occasion (NRF-80). During decontamination and dispositioning work at NRF in 1995, portions of the pipe were removed and contamination was detected in the soil. Cobalt-60 was detected up to 1,600 pCi/g and cesium-137 was detected up to 7 pCi/g.

Sampling was performed during the NRF Comprehensive RI/FS in an area likely to have been contaminated from a past pipe leak. Samples were collected from six boreholes to a depth of ten feet. The only COPC detected above risk-based concentrations was cobalt-60, which was detected at a maximum level of 14.56 pCi/g at an eight foot depth.

Some uncertainty exists with this site. The extent of contamination at NRF-80 is unknown. Past contamination is known to be present in the soil, but the contamination probably is sporadic making characterization sampling of the site very difficult. Process knowledge of the waste stream and sampling performed at discharge areas associated with this site suggest that the sampling performed in 1995 is not representative of all the contamination present at this site. Cesium-137 and strontium-90 have been detected above risk-based levels at other discharge areas associated with NRF-80. Therefore, a presumption is made that cesium-137 and stontium-90 are present in soils immediately beneath the depth of the remaining pipe at concentrations that exceed acceptable risk-based levels for a future 100-year resident.

3.2.2.18 A1W Processing Building Area Soil (NRF-81)

The A1W processing building area (NRF-81) is located west of the A1W prototype plant. The area contains several tanks and associated piping systems that were used to process radioactive effluent from the A1W plant. Several historical inadvertent releases have occurred in the area from past operations. Two known releases occurred in 1980 and 1982. Soil samples were collected from the area after the releases were cleaned up. In 1994, underground radioactive piping was removed from the processing building area during decontamination and dispositioning work at NRF. Soil samples were collected frequently during the excavation work and analyzed for radioactivity. No elevated radioactivity levels were found.

Sampling was not performed during the NRF Comprehensive RI/FS in this area because evidence suggests that past spills in the area were cleaned up and the area is very similar to other areas where surface spills occurred. Cesium-137 was detected at a maximum of 2.1 pCi/g and cobalt-60 was detected at a maximum of 1.4 pCi/g during past sampling. A conservative assumption was made that the maximum concentrations of other radionuclides detected at similar sites were present at this site. This includes 36.71 pCi/g of carbon-14, 0.94 pCi/g of plutonium-239, and 0.18 pCi/g of uranium-235.

The maximum extent of contamination at NRF-81 would be the upper three feet of soil and an area approximately 100 feet by 130 feet. The area represents a fenced in location around the processing building and the estimated size is considered conservative.

3.3 Site Characteristics (New Sites)

NRF-82 (Evaporator Bottom Tank Release) was an area identified after the NRF Comprehensive RI/FS was completed. This site consists of the soil surrounding an underground storage tank vault. The tank and its contents will be managed under other regulatory actions. One spill was known to have occurred at the area in 1972. The spill was cleaned up to the standards at that time and additional construction has occurred in the area. Slightly elevated amounts of radioactivity were reported after the cleanup was performed in 1972. Additional cleanup was performed in 1977. This site was evaluated in a Track 1 investigation and the risk was estimated to be low based on the Track 1 evaluation. This site had no impact on the cumulative risk assessment.

NRF-83 (ECF Hot Cells Release Area) was also an area identified after the NRF Comprehensive RI/FS was completed. The site is the location of a radioactive liquid release that occurred in 1972. Radioactive liquid was released from a pipe to a concrete trench. The soil below and adjacent to the trench became contaminated. Cleanup actions taken in 1972 did not include the soil below the trench. The contaminated soil was discovered in 1997 when a concrete pad adjacent to the concrete trench was removed during ECF Hot Cell upgrade work. Cobalt-60 and cesium-137 were present in the soil. An estimated 28 cubic meters of soil is contaminated with cobalt-60 and cesium-137 below the trench. This soil remains in place to preserve the structural integrity of the trench. All accessible contaminated soils adjacent to the south side of the trench were removed during the construction project and replaced with clean soil. A new concrete pad was poured at the location of the old concrete pad excavation as part of the Hot Cell upgrade work. The contaminated soil beneath the trench is not presently accessible and no exposure route is available. The site was evaluated in a Track 1 investigation and the risk was estimated to be low based on the Track 1 evaluation. This site had no impact on the cumulative risk assessment.

3.4 Groundwater Characteristics

The remedial investigation included a hydrogeologic study. This study consisted of a review of past hydrogeologic data from multiple studies, review and interpretation of seven years of groundwater data collected near NRF, groundwater flow modeling of the Snake River Plain Aquifer (SRPA), modeling of contaminant fate and transport, and developing groundwater contour, flow direction and contaminant migration maps. Information from the study was used in the risk assessments (summarized in Section 4) for evaluating the groundwater ingestion pathway. Several specific conclusions of the hydrogeologic study are highlighted below.

Groundwater modeling at NRF confirmed that NRF is located over a portion of the SRPA that possesses a lower gradient than the surrounding aquifer. The lower gradient (i.e., flatter water table) and accompanying slower water flow through the aquifer, both consequences of a less permeable aquifer, allow surface recharge from NRF operations to increase the elevation of the water table under NRF. The result is a lobed-shaped high in the water table on the east side of NRF. The high extends from the north side of NRF to the south side of NRF.

In 1994, a well fitness evaluation was performed at NRF to determine the quality of the wells used in the NRF groundwater monitoring network. At nearly the same time, NRF performed groundwater modeling, as outlined above, to assess aquifer flow paths near NRF and the optimal placement of groundwater monitoring wells. As a result of the fitness evaluation and modeling work, six new groundwater monitoring wells were constructed and were included in the NRF groundwater monitoring network. As of January 1996, the wells used in the groundwater monitoring network included five United States Geological Survey (USGS) wells and eight NRF wells. Of these wells, two are used to assess the general upgradient quality of the SRPA, two are used to assess the affects on groundwater of effluent discharged to the industrial waste ditch, and six are located in a semi-circular arc just south of NRF, and are used to sample the local SRPA water downgradient of NRF. The remaining three wells are located south of NRF and are used to sample the regional characteristics of the SRPA downgradient of NRF.

Samples have been collected from the NRF groundwater monitoring network since 1989. The recently constructed groundwater monitoring wells were specifically designed to monitor the upper 50 feet of the SRPA. Results obtained from analyses of samples collected from the USGS wells are primarily used for screening purposes, and verify that the new monitoring wells are sufficiently spaced so as to detect contaminants emanating from past or current activities at NRF.

Based on samples collected from nine downgradient wells, chromium, nitrates, tritium, and various salts were detected at slightly elevated levels. The average concentrations of these constituents occurring in groundwater monitoring wells downgradient of the source are as follows: chromium at 0.05 ppm, nitrates at 2.3 ppm, tritium at 308 picocuries per liter (pCi/l), and chloride (salt) at 226 ppm. Based on samples collected from 1989 to 1998, the chromium, nitrate, tritium, and salt concentrations show no apparent increasing trend.

Fate and transport modeling was performed using the GWSCREEN computer program. All contaminants detected at OU 8-08 sites above risk-based concentrations in the soil were included in modeling runs to assess their potential migration to the aquifer. No contaminants were predicted to reach the aquifer within 100 years under normal precipitation conditions. Additional fate and transport analyses of past and current aquifer recharge points (e.g., industrial waste ditch) were performed and concluded that the industrial waste ditch, active NRF sewage lagoon, and potential deep perched water associated with past discharges to the S1W Leaching Beds are the only NRF sites with appreciable quantities of contaminants currently migrating. Contaminants include trivalent chromium (industrial waste ditch), tritium (S1W Leaching Beds), nitrates (active sewage lagoon), and various salts (industrial waste ditch and active sewage lagoon).

Perched water was found to be present at several locations beneath NRF. Perched water is almost universally associated with substantial recharge due to infiltration associated with surface discharge. A perched water zone is currently found beneath the industrial waste ditch and another is located under the NRF sewage lagoon. The contaminants present in the perched water zones are reflective of their source. The industrial waste ditch perched water zone contains elevated levels of salts and chromium. Perched water beneath the sewage lagoon contains slightly elevated levels of nitrates, cations (e.g., sodium), and anions (e.g., chloride). Two former shallow perched water zones (approximately 20 to 30 feet) were known to exist (early 1960s) beneath the S1W and A1W Leaching Beds, but sampling performed during the remedial investigation show these perched water zones are no longer present.

Deep perched water (in excess of 100 feet) may currently exist beneath the S1W Leaching Beds. The elevated levels of tritium currently detected in samples from the groundwater monitoring wells nearest to the S1W Leaching Beds are probably due to residual deep perched water which contains small amounts of tritium. Tritium migrates in the environment as water; therefore, the majority of tritium released to the leaching beds has long since evaporated or migrated and dispersed into the SRPA. The remaining tritium associated with this deep perched water is gradually dispersing into the SRPA. This dispersion is slow because the recharge source (i.e., discharge to the leaching beds) is no longer present. Dispersion processes further lower tritium levels to below background in groundwater downgradient of NRF. Tritium levels found and monitored in wells located near the S1W Leaching Beds since 1996 are expected to decrease over time from decay, dilution, and depletion of the source.

The hydrogeologic study concluded that NRF has had a limited impact on the SRPA, primarily due to slightly elevated levels of chromium, nitrates, tritium, and various salts. Additionally, these constituents have not shown an increasing trend and are not expected to increase in the future.

4.0 Summary of Site Risks

Several different risk assessments were performed to evaluate the potential human health and environmental risks posed by the identified sites at NRF. Track 1 and Track 2 investigations were performed for OUs 8-01, 02, 03, 04, and 09 prior to the NRF Comprehensive RI/FS. The following risk assessments were performed as part of the NRF Comprehensive RI/FS: risk assessments for OU 8-08 sites not previously investigated, a cumulative risk assessment of all NRF sites, and an ecological risk assessment. The OU 8-08 site assessments evaluated the human health risk associated with contaminants present at each site. The cumulative risk assessment evaluated the potential cumulative, or additive, human health risks for receptors based on their proximity to multiple sites and potential for exposure from more than one site at a time. The ecological risk assessment evaluated the potential risk to ecological receptors.

The following sections describe the three different types of risk assessments performed at NRF. In addition, two new sites were identified after the NRF Comprehensive RI/FS and Track 1 risk assessments were performed on these sites.

4.1 Individual Site Risk Assessments

4.1.1 OUs 8-01, 02, 03, 04, and 09 Site Risk Assessments

A Track 1 or Track 2 investigation was performed for each site associated with OUs 8-01, 02, 03, 04, and 09 prior to the NRF Comprehensive RI/FS. The Track 1 investigations, including the determination of the level of risk (semi-quantitative), were performed using INEEL guidance manuals for conducting Track 1 and Track 2 investigations. These guidance manuals were developed under the direction of DOE, State of Idaho, and EPA Region 10 personnel and provide general guidance on toxicity assessment, exposure assessment, risk characterization, default exposure parameter, etc. Typical default exposure parameters used during the Track 1 or Track 2 risk assessments would be the same as those shown in Section 4.1.2.2.2, which discusses the exposure parameters used to assess OU 8-08 sites in the NRF Comprehensive RI/FS. The completed Track 1 or Track 2 investigation documents, which provide details of the risk assessments, are part of the Administrative Record (Appendix A provides a current list of documents available in the Administrative Record).

The risk assessments typically resulted in a low estimated risk or no hazardous source being present. The low estimated risk was due to the small amounts of contaminants present at the site or because an exposure to contaminants under current site conditions was not likely. Table 4 summarizes the risk assessments performed for the sites associated with OUs 8-01, 02, 03, 04, and 09. The table indicates if a source is present and the result of the risk assessment (identified as no risk, low risk, or acceptable risk). The table also shows if the resulting risk was due to no source being present, a small contaminant source being present, or current site conditions limiting exposure to contaminants at the site.

For those sites with no risk because no source is present or with a low or acceptable risk because the contaminant source is small, no remedial actions would be expected. For those sites with a low or acceptable risk because of current site conditions (contaminants inaccessible because of structures, soil covers, or administrative controls), maintaining those site conditions would be expected.

Table 4. Risk Assessment Summary Table for OUs 8-01, 02, 03, 04, and 09

Operable Unit	Site Number	Source Present	Estimated Risk	Basis for Risk Determination
OU 8-01				
	NRF-03	Yes	Low	Small Contaminant Source
	NRF-06	No	None	No Source
	NRF-08	No	None	No Source
	NRF-33	No	None	No Source
	NRF-40	No	None	No Source
	NRF-41	No	None	No Source
	NRF-63	No	None	No Source
OU 8-02				
	NRF-09	Yes	Low	Small Contaminant Source
	NRF-37	No	None	No Source
	NRF-38	No	None	No Source
	NRF-42	Yes	Low	Site Conditions
	NRF-47	No	None	No Source
	NRF-52A	Yes	Low	Small Contaminant Source
	NRF-52B	No	None	No Source
	NRF-54	No	None	No Source
	NRF-55	No	None	No Source
	NRF-61	Yes	Low	Site Conditions
	NRF-64	Yes	Low	Small Contaminant Source
	NRF-68	Yes	Low	Small Contaminant Source
OU 8-03				
	NRF-10	Yes	Acceptable	Small Contaminant Source
	NRF-15	Yes	Low	Small Contaminant Source
	NRF-18A	Yes	Low	Site Conditions
	NRF-18B	Yes	Low	Small Contaminant Source
	NRF-20	Yes	Low	Small Contaminant Source
	NRF-22	Yes	Low	Site Conditions
	NRF-45	Yes	Low	Small Contaminant Source
	NRF-56	No	None	No Source
OU 8-04				
	NRF-28	Yes	Low	Small Contaminant Source
	NRF-29	Yes	Low	Small Contaminant Source
	NRF-31	Yes	Low	Small Contaminant Source
	NRF-44	No	None	No Source
	NRF-58	Yes	Low	Small Contaminant Source
	NRF-62	No	None	No Source
	NRF-65	Yes	Low	Small Contaminant Source
	NRF-69	Yes	Low	Small Contaminant Source
	NRF-70	Yes	Low	Small Contaminant Source
	NRF-71	Yes	Low	Small Contaminant Source
	NRF-72	Yes	Low	Small Contaminant Source
	NRF-73	No	None	No Source
	NRF-74	Yes	Low	Small Contaminant Source
	NRF-75	Yes	Low	Small Contaminant Source
	NRF-76	Yes	Low	Small Contaminant Source
	NRF-77	Yes	Low	Small Contaminant Source
OU 8-09				
	None	Yes	Acceptable	Small Contaminant Source

4.1.2 OU 8-08 Site Risk Assessments

A human health risk assessment was performed for each of the 18 radiological areas that were not assessed in a previous investigation before the NRF Comprehensive RI/FS except for NRF-17 (S1W Retention Basins). The assessment included identifying COPCs for each site, an exposure assessment, a toxicity assessment, and a risk characterization. A risk assessment was not performed for NRF-17 because sampling was not done below the basins in the suspected area of potential contamination.

4.1.2.1 Identification of Contaminants of Potential Concern

Past sampling, process knowledge, discharge records, and sampling during the NRF Comprehensive RI/FS were used to develop a list of COPCs. Since soil is the media of concern, a soil concentration term was established for each COPC at each site. The concentration term was typically the maximum concentration detected during characterization sampling performed in 1991-92, recent sampling from the Environmental Monitoring Program, or RI/FS sampling. These sampling evolutions provided data with the proper data quality for use in risk assessment calculations. In a few cases where sufficient sample results existed, the concentration term was the 95% upper confidence limit of the mean, which provides a more balanced depiction of the contaminant concentrations present at a site. Historical sampling prior to 1990 was not generally used because the data collected did not meet CERCLA quality assurance requirements needed for risk assessment calculations. Data prior to 1990 was used if it was the only data available and sufficient quality control of the samples could be determined. The historical data did, however, provide valuable information on site locations and COPCs.

The concentration terms were compared to risk-based soil screening levels and background levels. Risk-based levels were based on concentrations in the soil corresponding to an increased cancer risk of 1 in 10,000,000 (1E-07) or a hazard quotient of 0.1. The terms increased cancer risk and hazard quotient are discussed later in this section. The risk-based screening levels for non-radiological constituents were obtained from the EPA Region III Risk-Based Concentration Table. The table contains reference doses and carcinogenic potency slopes (discussed in Section 4.1.2.3) which were taken from the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), and other EPA sources. These toxicity constants are combined with "standard" exposure scenarios to calculate risk-based concentrations. The risk-based level for lead is the EPA recommended screening level for lead cleanup (400 ppm). For radiological constituents, standard INEEL default exposure parameters were used and concentrations were calculated using standard INEEL Track 2 risk assessment equations given in the INEEL Track 2 guidance document. Background soil concentrations are INEEL published values. Those COPCs with a concentration term greater than background and risk-based levels were retained for evaluation in the risk assessment. Those contaminants with a concentration term less than background or risk-based levels were removed as COPCs.

4.1.2.2 Exposure Assessment

The exposure assessment estimates the magnitude of actual and/or potential receptor exposures, the frequency and duration of these exposures, and the pathways by which receptors are potentially exposed to various COPCs.

4.1.2.2.1 Exposure Scenarios

The human health risk assessment for each site evaluated residential and occupational scenarios. For the residential scenario, assessments were made for a receptor residing at the site 30 years and 100 years in the future. The future residential scenario assumes the site remains under Federal government control for at least 30 or 100 years. An assumption is also made that the contaminants present at the site are available to the residential receptor for exposure regardless of the depth. This takes into consideration the construction of a residence with a basement and the availability of the excavated soil for exposure.

A current and 30-year occupational scenario is also evaluated. Again, it is assumed that the contaminants are available for exposure regardless of the depth. The occupational scenario assumes that no controls are in place to prevent exposure to COPCs.

Soil ingestion, inhalation of fugitive dust, and external radiation exposure are the potential exposure pathways considered for the occupational and residential scenarios. In addition, the groundwater ingestion and food crop ingestion pathways are considered only for the residential scenario. For the occupational scenario, the food crop ingestion pathway is not a concern and, since the drinking water is continuously monitored, the groundwater ingestion pathway is not a concern. The dermal absorption pathway was qualitatively evaluated for the residential scenario.

4.1.2.2.2 Quantification of Exposure

Adult exposures were evaluated for all scenarios and pathways. Child exposures were considered separately only for the soil ingestion pathway in the residential scenario, because children are likely to ingest more soil than are adults.

The exposure parameters used in the risk assessment were obtained from EPA and DOE guidance. The exposure parameter default values used in the risk assessment are designed to estimate the reasonable maximum exposure at a site. Using this approach may tend to over-estimate the risk. Exposure duration and frequency are used to determine the total time of exposure. Exposure duration would be the number of years residing or working at a site, and exposure frequency is the number of hours per day and days per year that a receptor may be exposed to the site during the exposure duration period. The exposure parameters used in the risk assessment were:

Body Weight:
- Adult: 70 kilograms → 154 pounds
- Child: 15 kilograms → 33 pounds

Exposure Duration:
- Occupational: 25 years
- Residential: 30 years
  - Adult: 24 years
  - Child: 6 years

Exposure Frequency:
- Occupational: 8 hours per day, 250 days per year
- Residential: 24 hours per day, 350 days per year

Ingestion/Inhalation Rate:
- Soil Ingestion:
  - Occupational: 50 milligrams per day → size of ¼ aspirin tablet
  - Residential:
    - Adult: 100 milligrams per day → size of ½ aspirin tablet
    - Child: 200 milligrams per day → size of 1 aspirin tablet

Inhalation:

Occupational: 20 cubic meters per work day → equivalent to the volume of air in an 8 by 11 foot room by 8 foot high.

Residential: 20 cubic meters per day

Water Ingestion:

Residential: 2 liters per day

4.1.2.3 Toxicity Assessment

A toxicity assessment was conducted to identify potential adverse effects to humans from contaminants at NRF. A toxicity value is the numerical expression of the substance dose-response relationship used in the risk assessment. Toxicity values (slope factors and reference doses) for the sites were obtained from the EPA's IRIS database and EPA's HEAST. The reference dose is the toxicity value used to evaluate noncarcinogenic effects that result from exposure to chemicals, and is based on the concept that there is a threshold that must be reached before adverse effects occur. The slope factor is the toxicity value used to evaluate potential human carcinogenic effects. The slope factors have been derived based on the concept that for any exposure to a carcinogenic chemical, there is some risk of a carcinogenic response. The slope factor is used in a risk assessment for the purpose of estimating an upper bound lifetime probability of an individual developing cancer from the exposure to a specific level of a carcinogen.

4.1.2.4 Risk Characterization

Carcinogenic effects are calculated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. Generally, CERCLA cleanup decisions are based on carcinogenic excess risk levels slightly greater than 1 chance in 10,000 (1E-04) where excess risk is the possibility of contracting cancer above the national average. The target risk range for CERCLA sites is between 1E-04 and 1E-06 and represents an upper and lower risk level where a remedial action may be required if the agencies determine an action is justified. A remedial action is likely at risk levels greater than 1E-04. A risk less than 1E-06 is usually considered acceptable. A risk management decision on whether a remedial action is appropriate is made by the agencies when the calculated risk is between 1E-04 and 1E-06.

The potential for a noncarcinogenic effect is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a toxicity reference dose derived for a similar exposure period. The reference dose is a toxicity value representing the acceptable upper limit of a substance as determined by the Agencies based on various scientific studies. The ratio of exposure to the reference dose is called a hazard quotient. A hazard quotient less than one is considered acceptable, while a hazard quotient greater than one indicates a risk management decision is needed to determine if a remedial action is justified. The sum of all hazard quotients associated with a particular area is a hazard index. The calculation of the hazard index involves the use of uncertainty factors to ensure a large safety margin is present.

Table 5 summarizes the human health risk assessments performed for each site showing the contaminant, exposure pathway, and calculated risk or hazard quotient if the increased cancer risk was greater than or equal to 1E-06 or the hazard quotient was greater than or equal to 1. Some contaminants have both carcinogenic risks and noncarcinogenic effects, and therefore may have an increased carcinogenic risk and a hazard quotient (noncarcinogenic). Those constituents identified as COPCs during the site characterization for each site (Section 3.2.2), but which did not show a risk greater than 1E-06 or a hazard quotient greater than 1.0, are shown on Table 6 and were eliminated as COPCs.

Table 5. OU 8-08 Individual Site Risk Assessment Summary

Unit/Constituent	Current Occupational		30-year Occupational		30-year Residential		100-year Residential		Pathway[a]
	Risk	HQ	Risk	HQ	Risk	HQ	Risk	HQ	
<u>NRF-02</u> – Old Ditch Surge Pond (No Further Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Cesium-137	5e-05	NA	3e-05	NA	1e-04	NA	3e-05	NA	External Exposure[b] Ingestion of Food Crops[b]
Cobalt-60	4e-04	NA	7e-06	NA	4e-05	NA	--	NA	External Exposure
<u>NRF-13</u> - S1W Temporary Leaching Pit (No Action site)									
No risks greater than 1e-06 or HQ greater than 1.0									
<u>NRF-23</u> – Sewage Lagoons (No Further Action site)									
Arsenic	7e-06	--	7e-06	--	8e-05	--	8e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Mercury[c]	NA	--	NA	--	NA	6.6	NA	6.6	Ingestion of Food Crops[b]
Cesium-137	4e-05	NA	2e-05	NA	1e-04	NA	2e-05	NA	External Exposure[b] Ingestion of Food Crops[b]
Cobalt-60	2e-05	NA	--	NA	2e-06	NA	--	NA	External Exposure
<u>NRF-79</u> - ECF Water Pit Release (No Action site)									
Cesium-137	NA	NA	NA	NA	1e-05	NA	3e-06	NA	Ingestion of Groundwater[b]
Cobalt-60	NA	NA	NA	NA	7e-06	NA	--	NA	Ingestion of Groundwater
Tritium	NA	NA	NA	NA	5e-05	NA	--	NA	Ingestion of Groundwater
Nickel-63	NA	NA	NA	NA	3e-06	NA	2e-06	NA	Ingestion of Groundwater[b]
Strontium-90	NA	NA	NA	NA	3e-06	NA	--	NA	Ingestion of Groundwater

Unit/Constituent	Current Occupational		30-year Occupational		30-year Residential		100-year Residential		Pathway[a]
	Risk	HQ	Risk	HQ	Risk	HQ	Risk	HQ	
<u>NRF-81</u> - A1W Processing Building Area Soil (No Further Action site)									
Cesium-137	3e-05	NA	1e-05	NA	7e-05	NA	1e-05	NA	External Exposure[b] Ingestion of Food Crops[b]
Cobalt-60	8e-05	NA	2e-06	NA	8e-06	NA	--	NA	External Exposure
Uranium-235	--	NA	--	NA	1e-06	NA	1e-06	NA	External Exposure[b]
<u>NRF-14</u> - S1W Leaching Beds[d] <u>NRF-12B</u> - S1W Leaching Pit (Remedial Action sites)									
Arsenic	3e-05	--	3e-05	--	3e-04	1.6	3e-04	1.6	Ingestion of Soil[b] Ingestion of Food Crops[b]
Mercury	NA	--	NA	--	NA	10	NA	10	Ingestion of Food Crops[b]
Americium-241	--	NA	--	NA	5e-06	NA	5e-06	NA	Ingestion of Soil[b] Ingestion of Food Crops[b]
Cesium-137	2e-02	NA	1e-02	NA	7e-02	NA	1e-02	NA	Ingestion of Soil[b] Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	2e-02	NA	4e-04	NA	2e-03	NA	--	NA	Ingestion of Soil Ingestion of Food Crops External Exposure
Neptunium-237	--	NA	--	NA	1e-05	NA	1e-05	NA	Ingestion of Food Crops[b]
Nickel-63	--	NA	--	NA	7e-06	NA	5e-06	NA	Ingestion of Food Crops[b]
Plutonium-238	--	NA	--	NA	3e-06	NA	2e-06	NA	Ingestion of Soil[b]
Strontium-90	1e-06	NA	--	NA	1e-03	NA	9e-04	NA	Ingestion of Soil Ingestion of Food Crops[b]

Unit/Constituent	Current Occupational		30-year Occupational		30-year Residential		100-year Residential		Pathway[a]
	Risk	HQ	Risk	HQ	Risk	HQ	Risk	HQ	
NRF-19 - A1W Leaching Bed (Remedial Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Americium-241	3e-06	NA	2e-06	NA	2e-05	NA	2e-05	NA	Ingestion of Soil[b] Ingestion of Food Crops[b] External Exposure[b]
Cesium-137	2e-02	NA	8e-03	NA	4e-02	NA	9e-03	NA	Ingestion of Soil[b] Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	7e-03	NA	1e-04	NA	7e-04	NA	--	NA	External Exposure[b]
Plutonium-238	2e-06	NA	1e-06	NA	9e-06	NA	5e-06	NA	Ingestion of Soil[b] Ingestion of Food Crops[b]
Nickel-63	--	NA	--	NA	7e-06	NA	5e-06	NA	Ingestion of Food Crops[b]
Strontium-90	1e-05	NA	6e-06	NA	9e-03	NA	2e-03	NA	Ingestion of Soil[b] Ingestion of Food Crops[b]
NRF-12A – Underground Piping Leading to S1W Leaching Pit (Remedial Action site)									
Mercury	NA	--	NA	--	NA	17	NA	17	Ingestion of Food Crops[b]
Cesium-137	9e-02	NA	4e-02	NA	2e-01	NA	4e-02	NA	Ingestion of Soil[b] Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	6e-03	NA	1e-04	NA	6e-04	NA	--	NA	External Exposure
Nickel-63	--	NA	--	NA	3e-06	NA	2e-06	NA	Ingestion of Food Crops[b]
Plutonium-244	1e-06	NA	1e-06	NA	7e-06	NA	7e-06	NA	External Exposure[b]
Strontium-90	--	NA	--	NA	4e-04	NA	7e-05	NA	Ingestion of Soil Ingestion of Food Crops[b]

Unit/Constituent	Current Occupational		30-year Occupational		30-year Residential		100-year Residential		Pathway[a]
	Risk	HQ	Risk	HQ	Risk	HQ	Risk	HQ	
NRF-11[e] - S1W Tile Drainfield (Remedial Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Cesium-137	4e-06	NA	2e-06	NA	1e-05	NA	2e-06	NA	External Exposure[b]
Cobalt-60	2e-04	NA	3e-06	NA	1e-05	NA	--	NA	External Exposure
NRF-11 (continued) L-Shaped Sump[f] (Remedial Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Cesium-137	5e-04	NA	3e-04	NA	1e-03	NA	3e-04	NA	Ingestion of Soil Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	7e-05	NA	1e-06	NA	6e-06	NA	--	NA	External Exposure
Manganese-54	1e-06	NA	--	NA	--	NA	--	NA	External Exposure
Plutonium-244	--	NA	--	NA	3e-06	NA	3e-06	NA	External Exposure[b]
NRF-21A – Old Sewage Basin (Remedial Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Antimony	NA	--	NA	--	NA	1.8	NA	1.8	Ingestion of Soil[b]
Mercury	NA	--	NA	--	NA	27	NA	27	*Ingestion of Food Crops[b]*
N-nitrosodi-n-propylamine	1e-06	NA	1e-06	NA	1e-05	NA	7e-04	NA	Ingestion of Soil[b] Ingestion of Groundwater[b]
Cesium-137	3e-03	NA	1e-03	NA	8e-03	NA	1e-03	NA	Ingestion of Soil[b] Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	1e-04	NA	3e-06	NA	1e-05	NA	--	NA	External Exposure

Unit/Constituent	Current Occupational		30-year Occupational		30-year Residential		100-year Residential		Pathway[a]
	Risk	HQ	Risk	HQ	Risk	HQ	Risk	HQ	
NRF-43 - Seepage Basin Pump Out Area (No Further Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Cesium-137	2e-05	NA	8e-06	NA	4e-05	NA	9e-06	NA	Ingestion of Food Crops External Exposure[b]
NRF-21B - Sludge Drying Bed (Remedial Action site)									
Mercury	NA	--	NA	--	NA	37	NA	37	Ingestion of Food Crops[b]
Benzo(a)pyrene	--	NA	--	NA	1e-06	NA	1e-06	NA	Ingestion of Soil
Cesium-137	5e-04	NA	3e-04	NA	1e-03	NA	3e-04	NA	Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	6e-05	NA	1e-06	NA	6e-06	NA	--	NA	External Exposure
Uranium-235	--	NA	--	NA	1e-06	NA	1e-06	NA	External Exposure[b]
NRF-16 - S1W Radiography Building Collection Tanks (No Further Action site)									
Arsenic	2e-06	--	2e-06	--	3e-05	--	3e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
Benzo(a)pyrene	--	NA	--	NA	3e-06	NA	3e-06	NA	Ingestion of Soil[b]
Cesium-137	1e-04	NA	6e-05	NA	3e-04	NA	8e-05	NA	Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	2e-05	NA	--	NA	2e-06	NA	--	NA	External Exposure
Uranium-235	--	NA	--	NA	1e-06	NA	1e-06	NA	External Exposure[b]
NRF-66 - Hot Storage Pit (No Further Action site)									
Cesium-137	2e-05	NA	1e-05	NA	3e-05	NA	2e-06	NA	Ingestion of Food Crops External Exposure[b]

Unit/Constituent	Current Occupational		30-year Occupational		30-year Residential		100-year Residential		Pathway[a]
	Risk	HQ	Risk	HQ	Risk	HQ	Risk	HQ	
NRF-80[e] - A1W/S1W Radioactive Line Near BB19 (Remedial Action site)									
Cesium-137	8e-05	NA	4e-05	NA	2e-04	NA	4e-05	NA	Ingestion of Food Crops[b] External Exposure[b]
Cobalt-60	9e-02	NA	2e-03	NA	9e-03	NA	--	NA	Ingestion of Soil Ingestion of Food Crops External Exposure
NRF-32 - S5G Basin Sludge Disposal Bed (No Action site)									
Arsenic	2e-06	--	2e-06	--	2e-05	--	2e-05	--	Ingestion of Soil[b] Ingestion of Food Crops[b]
NRF-17[e] – S1W Retention Basins (Remedial Action Site)									
No risk assessment was performed for this site.									

a) Pathways that showed a carcinogenic risk of 1 x 10^{-6} or greater risk or a hazard quotient of 1.0 or greater. If no single pathway showed greater than 1 x 10^{-6} risk or a hazard quotient of 1.0, the pathway that contributes most to the constituent overall risk is shown.
b) These pathways show a risk greater than 1 x 10^{-6} or a hazard quotient greater than 1.0 at the 100-year residential scenario.
c) A risk management decision was made, based on the conservative nature of the risk assessment, to eliminate mercury as a contaminant of concern for this site even though the hazard quotient was calculated as greater than 1.0. (See discussion in Section 4.1.2.6)
d) NRF-14 and NRF-12B were evaluated as one area because of their close proximity to each other and similar history and discharges.
e) An unacceptable risk is presumed to exist at these sites based on process knowledge and sampling results from downstream units.
f) S1W Tile Drainfield and L-Shaped Sump were evaluated separately.

NA Not Applicable
HQ Hazard Quotient
-- Risk was below 1 x 10^{-6} or hazard quotient was less than 1.0.

Table 6. Contaminants Eliminated as Contaminants of Potential Concern

Site	Contaminant with Risk < 1E-06 or HQ < 1.0
NRF-02	Chromium
NRF-11 (S1W Tile Drainfield)	Dieldrin
NRF-11 (L-Shaped Sump)	Americium-241 Americium-243
NRF-12A	Chromium Americium-241 Carbon-14 Plutonium-238 Plutonium-239
NRF-12B, 14	Aroclor-1260 Carbon-14 Plutonitum-239 Chromium
NRF-13	Arsenic Cesium-137 Cobalt-60
NRF-16	Benz(a)anthracene Benzo(b)fluoranthene Indeno(1,2,3-CD)pyrene
NRF-19	Chromium Carbon-14 Plutonium-239 Uranium-234
NRF-21A	Cadmium Chromium Silver
NRF-21B	Antimony Cadmium Chromium Silver Benzo(b)fluoranthene
NRF-23	Cadmium Chromium Silver Benz(a)anthracene
NRF-43	Carbon-14 Plutonium-239
NRF-79	Carbon-14 Manganese-54
NRF-81	Carbon-14 Plutonium-239

4.1.2.5 Risk Assessment Uncertainties

There are many uncertainties associated with the risk assessment calculations. Uncertainties are associated with all estimates of carcinogen and noncarcinogen health hazards. These uncertainties result from incomplete knowledge of many physical and biological processes and assumptions made on such items as land usage and availability of contaminants. Where specific information is not available, it is necessary to make assumptions and/or use predictive models to compensate for lack of information. The assumptions, models, and calculations are chosen so that the resulting risk and hazard estimates are protective of human health. However, these assumptions usually result in a conservative estimate of risk. Table 7 shows the uncertainties associated with various aspects of the risk assessment performed for the individual sites.

Table 7. Uncertainties Associated with Individual Site Risk Assessments

Area	Uncertainties	Effect on Risk
Sampling and Analysis	All constituents, or their maximum values, may not have been identified.	Underestimate
	A representative concentration may not have been obtained where limited sampling was performed.	Overestimate or Underestimate
Concentration Terms	Maximum values are used in the risk assessments.	Overestimate
	All risk assessments use one-half the detection limits when the constituent is not detected.	Overestimate
Fate and Transport	Use of generic modeling parameters may not be truly representative of NRF.	Overestimate
	Distribution coefficient values have wide ranges for various soil types.	Overestimate
	Chemical compounds are indeterminate.	Underestimate or Overestimate
	Physical parameters of soil on which analysis performed not known.	Underestimate or Overestimate
	The presence of oil and organics in the effluent complicate fate and transport determination.	Underestimate or Overestimate
GWSCREEN Modeling (used for assessing groundwater pathway)	Peak concentration times of constituents that occur over 10,000 years in the future are not included in the risk assessments.	Underestimate
	GWSCREEN input parameters (i.e., contaminant solubility limit, distribution coefficient (K_d), and infiltration rate) are considered conservative, but contain some uncertainty.	Underestimate or Overestimate
	Maximum source term concentrations are assumed for the entire volume modeled for each site.	Overestimate

Area	Uncertainties	Effect on Risk
Exposure Assessment	Assumes residences could be established in areas that are uninhabitable due to physical or administrative limitations.	Overestimate
	Default exposure values assume maximum possible exposure times, particularly for the occupational scenario where exposure times were 8 hours per day rather than more realistic times of a maximum of a few hours a week.	Overestimate
	The dermal absorption pathway was not included in the risk assessment calculations.	Underestimate
	Withdrawn values from IRIS or HEAST are used in the risk assessments.	Underestimate or Overestimate
	Assumes that maximum constituent concentrations are present for all pathways.	Overestimate
Toxicity Assessment	Use of parent nuclide slope factor plus daughter (D) rather than adding slopes for both.	Underestimate
	Extrapolation of values from nonhuman studies to humans, from high doses to low doses.	Overestimate or Underestimate
	Route-to-route extrapolations are used.	Underestimate or Overestimate
	Lead was not included in the risk assessment calculations.	Underestimate
	Chromium was assumed, based on sample data, to be present in the trivalent state and not the more toxic hexavalent state.	Underestimate
	An assumption is made of the chemical form.	Underestimate or Overestimate
Risk Characterization	Risks are added across constituents and pathways, although they may not affect the same target organ or mechanisms of damage.	Underestimate or Overestimate
	Assumption that constituents are evenly distributed at maximum concentrations throughout the source volume.	Overestimate
	Toxicity values for some constituents (chromium, silver) are based on industrial conditions.	Overestimate
	Reference doses and slope factors were not adjusted from oral to dermal toxicity for the dermal pathway.	Underestimate

4.1.2.6 Individual Site Risk Assessment Conclusions

The INEEL future land use document states that the most likely land use scenario for the area around NRF will be industrial for the next 100 years. Land use is a consideration when determining the appropriate level of risks within an area of concern. NRF maintains strict control over the radiological areas identified in OU 8-08. Adequate management and operational controls are in place to control exposure at sites that show a potential risk to a current or 30-year occupational receptor. Cobalt-60 was one of the primary COPC for the occupational scenarios. However, with a half-life of near five years, the cobalt-60 will have decayed to insignificant amounts within 100 years which would be the earliest a residence at NRF could be expected. Most of the sites that show an elevated risk are subsurface soil contaminated areas and excavation would be required for exposure to contaminants. NRF-12B, 19, and 14 are outside the NRF security fence, but have separate surrounding fences to prevent any human contact with the contaminants even though the contaminants are primarily subsurface. The risk assessments used default exposure parameters to determine the likely risk to an occupational receptor. These default parameters assume the receptor will be in the area for eight hours a day and 250 days a year. The default values are conservative compared to the actual time an occupational receptor would be at the OU 8-08 sites. The typical occupational receptor at NRF would rarely visit these sites (i.e., annual environmental monitoring and sampling, which requires two to four individuals less than eight hours per year, are the only times individuals enter the areas). Based on the above information, the 100-year residential scenario is the scenario of concern.

The contaminants of concern (COCs) are those constituents that show a risk above the NCP target risk range of 1E-04 to 1E-06 or a hazard quotient greater than 1.0 for the 100-year residential scenario. Those constituents that show a carcinogenic risk above 1E-06 or a hazard quotient above 1.0 for the individual site risk assessments include: arsenic, antimony, mercury, benzo(a)pyrene, n-nitrosodi-n-propylamine, americium-241, cesium-137, neptunium-237, nickel-63, plutonium-238, plutonium-244, strontium-90, and uranium-235.

Groundwater risks were evaluated using the GWSCREEN modeling program and by evaluating samples collected from a network of groundwater monitoring wells (Figure 3). The GWSCREEN modeling assessed residual contamination in the soil and the ability of the contaminants to migrate toward the aquifer. GWSCREEN modeling did not show any contaminants reaching the groundwater during the 100-year residential scenario, with the exception of n-nitrosodi-n-propylamine (at 114 years), for the individual OU 8-08 sites that do not have a current water source to drive contaminants toward the groundwater. GWSCREEN used very conservative modeling parameters, however, many of the radiological contaminants were shown to decay to below risk-based concentrations prior to reaching the aquifer.

Groundwater samples were also evaluated to assess those contaminants that may have reached the aquifer because a driving force is currently present (e.g., industrial waste ditch) or was present at one time (e.g., S1W Leaching Beds). Although some elevated levels of contaminants have been detected during sampling (see Section 3.4), none of the average concentration of contaminants were found to be above the stringent maximum contaminant levels (MCLs) of federal drinking water standards. These MCLs are based on allowable risk levels established by the EPA. The GWSCREEN and groundwater sampling show the groundwater pathway is not a pathway of concern at NRF.

Arsenic, antimony, mercury, benzo(a)pyrene, and n-nitrosodi-n-propylamine were eliminated as COCs for various reasons during risk management decisions. Risk assessment calculations for all five contaminants were very conservative in nature and likely overestimated the risks. The maximum detected concentration for each contaminant was generally used for risk assessments and it was assumed the entire area was contaminated at that level. Antimony and n-nitrosodi-n-propylamine were COPCs at one site based on one sample collected below a 10 foot depth, which is the depth that would eliminate most exposure pathways. Mercury was assumed to be in the most toxic form (methylmercury) even though this is very unlikely at NRF. Benzo(a)pyrene risks were calculated to be equal to or slightly greater than 1E-06 at two sites and sample results may not have been representative of the areas sampled (e.g., sample results from sediment in a concrete enclosed sump were used to estimate surrounding soil contamination even though there was no evidence of sump leakage). There was no known process release of arsenic at NRF and the background levels, which are used to screen potential contaminants, may be higher than published. In addition, the site with the highest calculated arsenic risk is an area where remedial action was anticipated (NRF-12B).

A risk assessment was not performed for lead, which was detected at one location (NRF-12B) above EPA recommended screening levels for lead cleanup. Lead was retained as a COC.

Those sites that contain or potentially contain one or more COC above the target risk range are identified as sites of concern. The sites of concern include:

- NRF-11, S1W Tile Drainfield and L-shaped Sump
- NRF-12A, Underground Piping to Leaching Pit
- NRF-12B, S1W Leaching Pit
- NRF-14, S1W Leaching Beds
- NRF-17, S1W Retention Basins
- NRF-19, A1W Leaching Bed
- NRF-21A, Old Sewage Basin
- NRF-21B, Sludge Drying Bed
- NRF-80, A1W/S1W Radioactive Line Near BB19

NRF-17, NRF-80, and the drainfield portion of NRF-11 were the only sites that did not show a risk above 1E-04. They are retained as sites of concern because of their potential to contain COCs above risk-based levels. NRF-80 is an underground pipe and NRF-17 is a concrete basin and both may have leaked in the past. The drainfield portion of NRF-11 was used for radioactive discharges in the early 1950s. A risk assessment for the soil below NRF-17 (S1W Retention Basins) was not performed because of the lack of sample data and the difficulty associated with collecting samples in this area. Sampling results from NRF-80 and NRF-11 (drainfield portion) may not be representative of present site conditions because NRF-80 represents potential sporadic contamination, making characterization sampling very difficult, and the underground piping at NRF-11 could not be found using geophysical surveys prior to sampling. NRF-17 and NRF-80 are retained as sites of concern because of the uncertainty associated with the potential leaks. The drainfield portion of NRF-11 is also retained as a site of concern because of the uncertainty with the location of the underground piping and associated contaminated soil. At each location, contamination above risk-based concentrations is presumed based on process knowledge and sampling performed downstream of sites NRF-17 and NRF-80.

For sites NRF-13, 32, and 79, the low risks are due to the small amounts of contaminants present. For sites NRF-02, 16, 23, 43, 66, and 81 the low risks are due to the relatively small amounts of contaminants present, the protective nature of present site conditions (contaminants inaccessible because of structures, soil covers, or administrative controls), and the assumption of 100 years of industrial control.

4.1.3 New Site Risk Assessments

Track 1 investigations were performed for sites NRF-82 and NRF-83. The assessments determined that a source was present at each site, but current site conditions limit exposure to the sources. For NRF-82, industrial control for 100 years is assumed and this results in a low estimated risk. For NRF-83, no exposure route is present from the contaminant to a receptor because the contamination is presently below a concrete pad. Since the assessment of these two areas was made after the NRF Comprehensive RI/FS, an additional evaluation was made to determine the potential impact of these two sites to the cumulative risk assessment of NRF. Each site was determined not to impact the cumulative risk assessment because of the small amount of contamination present at NRF-82 and the lack of an available exposure route at NRF-83.

4.2 Ecological Risk Assessment

A Screening Level Ecological Risk Assessment (SLERA) evaluated the known or potential sites at NRF where previous investigations and sampling had determined that a source of contamination remained. Risks were calculated for six representative wildlife species based on an INEEL guidance manual for performing SLERAs. Organic, inorganic, and radiological constituents were evaluated through the ingestion and external exposure pathways. Assessment results were used to compare risks. Calculated screening level quotients were not considered to be additive because of the potential for compounding the uncertainty.

Based on the results of samples collected since 1987 and toxicity values used at other INEEL facilities, the metals arsenic, lead, and mercury were the risk drivers for ecological receptors at NRF. Radionuclides and organics were also contributors to the overall ecological risk, but the risks were very low. No additional ecological risk assessment was deemed necessary for radionuclide and organic compounds. NRF-23 (Sewage Lagoons) presented the highest potential ecological risk based on accessibility, attractiveness, number of constituents present, and associated risk.

The results of the SLERA were also used to select receptors for additional ecological risk assessment. Receptors were selected on the basis of potential exposure and perceived value to society. The SLERA determined that deer mice, bald eagles, and mallard ducks were the primary receptors of concern. Deer mice were calculated to receive some of the highest exposures in the vicinity of NRF. Bald eagles were selected because they prey upon deer mice, are a threatened species, and are perceived as a valued species by the general public. Mallards were a receptor of concern because they breed in the vicinity of the sewage lagoon, can be prey for bald eagles, and are a game species.

The ecological risk assessment addressed the effects of arsenic, lead, and mercury on the three receptors identified in the SLERA. Exposure values for these metals were calculated for each receptor and compared to a range of exposure values that resulted in no observable adverse effects to laboratory test animals. These comparisons were qualitatively assessed, since no studies were found that directly measured the effects of arsenic, lead, and mercury on the receptor species. The weighted average concentration for each of these constituents at NRF was also compared to background levels. The risks associated with the exposures to the ecological receptors are characterized as low. Although there are uncertainties associated with this screening assessment, the results indicate that no additional actions are required due to estimated risks to ecological receptors.

4.3 Cumulative Risk Assessment

A cumulative risk assessment was performed to determine if there are additional risks due to the cumulative, or additive, effects associated with having several individual sites near one another. The cumulative risk assessment evaluated all sites previously assessed and the OU 8-08 sites assessed during the NRF Comprehensive RI/FS. This included the 13 COCA sites evaluated prior to the FFA/CO and the 10 sites in OUs 8-04, 05, and 07 associated with a previous ROD. Each site was evaluated and screened out of the process if no constituent source was present or if the constituent concentrations were below screening levels. Screening levels corresponded to an excess cancer risk of 1E-07 or a hazard quotient of 0.1.

The 100-year future occupational worker and 100-year future resident were the scenarios considered for the cumulative risk assessment. The exposure pathways considered were inhalation of fugitive dust, ingestion of groundwater, and direct radiation exposure. The soil ingestion and food crop ingestion pathways were not considered because they are not likely to occur from more than one release site at a time.

The cumulative risk assessment identified that chromium, n-nitrosodi-n-propylamine, and cesium-137 are the only constituents that showed a calculated risk value greater than 1E-06 or a hazard quotient greater than 1.0 for the scenarios evaluated. Although chromium and n-nitrosodi-n-propylamine showed elevated risk values during the 100 year scenarios, they are not considered COCs at NRF. A hazard quotient of 3.5 through the inhalation pathway was calculated for chromium. The concentration source term used for chromium was very conservative (i.e., maximum values from most sites). Considering the conservative nature of the cumulative risk assessment and the fact that the hazard quotient for chromium was less than an order of magnitude greater than 1.0, a risk management decision was made that chromium is not a COC. N-nitrosodi-n-propylamine was detected at only one location at the 20 foot depth. It was eliminated as a COC during the individual site risk assessment. The estimated risk value for cesium-137 through the direct exposure pathway is 2E-4 for the occupational scenario and 1E-3 for the residential scenario. Cesium-137 was identified as a COC in the individual site risk assessments.

In addition to the uncertainties identified in Section 4.1.2.5 for the individual site risk assessments, there are uncertainties associated with the cumulative risk assessment. To assess cumulative effects, theoretical areas were defined that represented the total area of sites. The concentration for each constituent in the theoretical area (the source term) was then estimated using a weighted average of the highest concentration found in each area. This is a very conservative source term estimate. Additionally, the groundwater transport model tends to overestimate the groundwater concentration that further adds to the conservatism of the risk assessment calculations. The estimated risk values are believed to overestimate the risk from these areas.

The cumulative risk assessment shows that the individual risk assessments do not underestimate the risk. No additional COCs were identified when considering cumulative effects from the many individual sites at NRF that would impact decisions made on a site by site basis. Actions taken on individual sites will be adequate for WAG 8 as a whole. The cumulative assessment also determined that the decisions made for the 13 COCA sites (all No Action) and the 10 sites associated with a previous ROD (three landfill covers and seven No Actions) were appropriate and no additional action is necessary for the sites.

4.4 Risk Assessment Conclusions

The risk assessment process described above identified nine sites of concern (all of which are OU 8-08 sites) that have or potentially have unacceptable risks to human health. In addition, 55 sites were found to have no risk or an acceptable risk. Sixteen of the 55 sites had no hazardous source present and, therefore, no risk. Twenty-seven of the 55 sites have a low or acceptable risk because of the small amount of contaminants present or potentially present. Twelve of the 55 sites have a low risk primarily because of site conditions (industrial control assumed for 100 years or no exposure route from contaminants to receptors are present). The cumulative assessment did not identify any additional sites of concern and concluded that the decisions made for 23 sites (13 COCA sites and 10 sites from a previous ROD) were appropriate. The ecological risk assessment determined that risks associated with exposures to ecological receptors are low, indicating no additional actions are required due to estimated risks to ecological receptors. The sites of concern are shown on Figure 4 with respect to NRF.

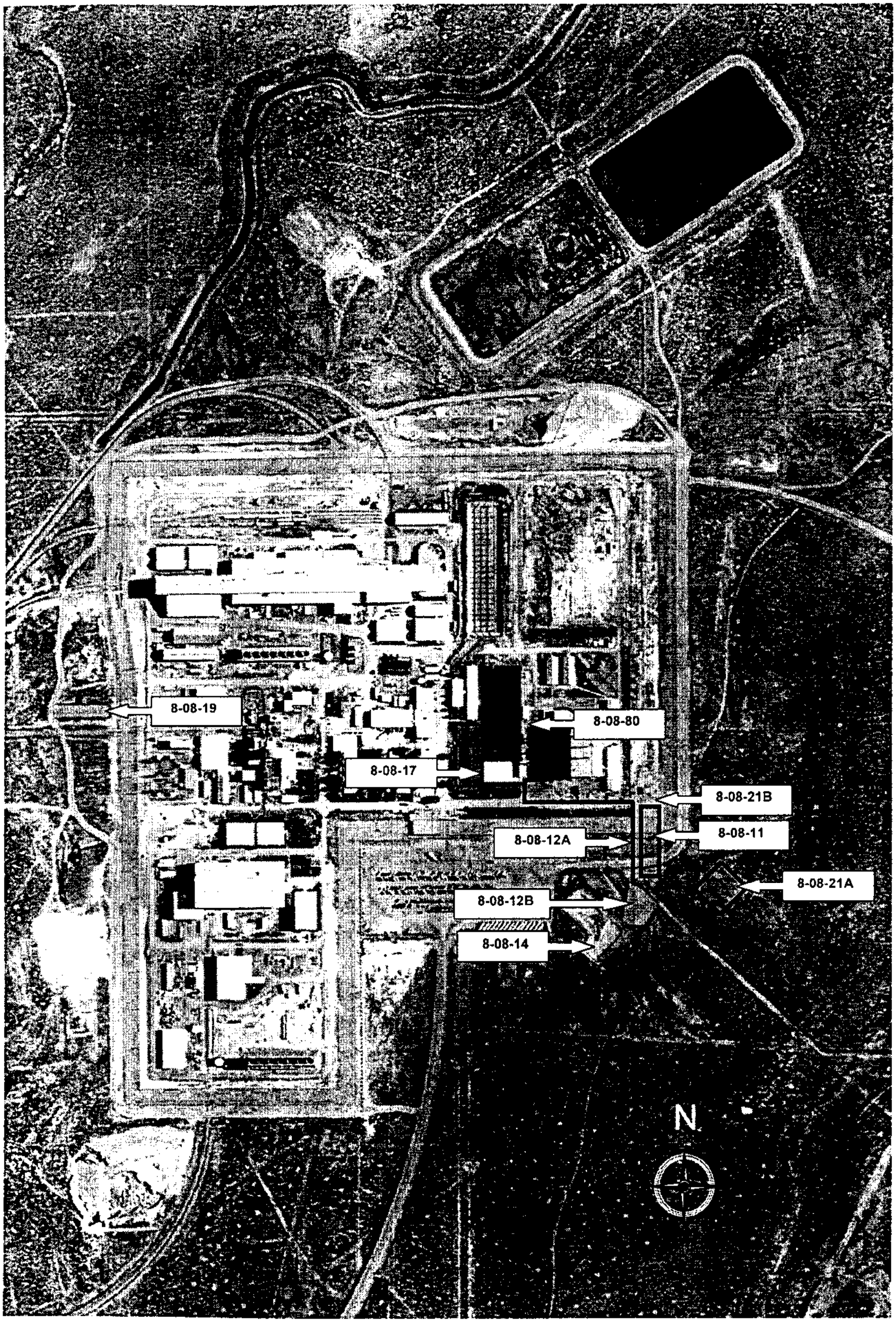

Figure 4. Overhead Photograph of Sites of Concern at the Naval Reactors Facility